ANNUAL SCIENTIFIC REPORT 1977-78

TEA RESEARCH ASSOCIATION, CALCUTTA

Our Cover

Vesicular and Arbiscular Mycorrhiza in Young Tea Root

TEA RESEARCH ASSOCIATION

Annual Scientific Report

The Tocklai Experimental Station of the Tea Research Association has pleasure in presenting the Annual Scientific Report (Part II) for the period 1st April, 1977 to 31st March, 1978. The Annual Administrative Report (Part I) of the Association for the same period is being issued separately from T.R.A., Calcutta.

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Director's Report

(1st April 1977 to 31st March 1978)

Tocklai is very closely associated with the tea industry. The changes in the industry are naturally reflected in Tocklai. During the recent past marked changes have taken place in T.R.A. membership and consequently in Tocklai.

TRA Membership

The membership strength of Tea Research Association has increased by 31 estates in the last one year alone, to 771 in 1977-78, as against only 535 in 1972-73. The yield of the member estates averaged 1640 kg/ha made tea which is 135% of 1211 kg/ha harvested by the non-member estates. The widening difference in the tea yield of member and the non-member estates has continued to grow. The production of North East Indian tea reached the highest ever level of 417 million kg in 1977 as compared to only 366 million kg in 1972-73. The sharp rise in both the yield and the production of made tea in the North East Indian tea industry in general, and of the member estates in particular, is a proof of the keen interest evinced by the planters in utilising Tocklai's know how and Advisory services.

Tocklai

So that the industry may get the requisite R & D support from T.R.A. for meeting its objectives of 1400 million kg production of good quality tea by 2000 AD, the TRA Council of Management recently decided to increase its financial support to Tocklai and its Sub-Stations by investing over the next 5 years a sum of Rs. 70 lakhs annually for non recurring expenditure on equipment and infrastructure. The $ 100,000 UNDP financed project on drainage is in full swing. A plan proposal for aid from Overseas Development Ministry, U.K. has been submitted for strengthening research at Tocklai through twinning arrangements with counterpart research institutions in the U.K. There is a likelihood of the proposal being accepted and of extra funds flowing to Tocklai for development of its research infrastructure.

In an organizational shake up of the Council of Scientific and Industrial Research which saw all Research Associations detached from the CSIR family, Tea Research Association was the only Research Association which continued to be with the CSIR. This helped Tocklai to forge closer linkages with the other CSIR laboratories, thus enlarging its infrastructural base for undertaking intensive research in new areas.

Plans of converting three Advisory Centres *viz.* Nagrakata, Silcoorie, Thakurbari into Sub Stations, has been finalised and approved by the Council for implementation. This is a major step towards carrying research to different agroclimatic conditions and providing expert advice to the planters within easy reach.

On 31st March 1978 Tocklai had 34 specialists and 139 research assistants and research fellows as against only 22 specialists and 106 research assistants in 1972-73. But the number of scientific personnel alone is not indicative of quality which has undergone a remarkable change. As against 29 post-graduates and doctorates on its roll in 1972, Tocklai had 59 post-graduates and doctorates on 31st March 1978 amongst its scientific cadres.

Programme of work

For the first time in Tocklai, perspective planning was systematised in macro as well as micro scales for implementing long and short term research projects. The objectives of the Station were redefined and set forth for drawing up the programme of work to meet the needs of the industry. These objectives are :

(a) to increase the yield of young and old tea bushes,

(b) to improve the quality of the finished product,

(c) to modernise manufacture of tea and to make it a continuous process, and

(d) to disseminate the results of research amongst the tea growers through a network of extension services, publications, lecture courses, seminars and symposia.

Accordingly the five year programme of research and other activities of Tocklai and its Sub-Stations for the period 1978-83 has been drawn up and is ready to be placed before the Council of Management for determining the priorities.

The research work carried out at the Station during the previous five year period (1973-78) was evaluated. Programme evaluation and review of research with PERT charts have been started. Systematic evaluation of progress will now be undertaken soon.

Interaction with the Planning Division of C.S.I.R. has been systematised in respect of providing information regarding technologies and processes developed at Tocklai, details of current projects, inter-institutional linkages with the C.S.I.R. and other institutes etc.

Personnel

We have assiduously built up the quality of our scientific personnel. The number of post graduates has tripled over the last 5 years amongst the scientific assistants. During the year 1977-1978, six officers, one each in soil drainage, plant physiology, planning and three in Advisory and 25 research assistants joined Tocklai.

To improve the training of scientific personnel, Tocklai held a workshop on research and development where a strong faculty was invited from industry, C.S.I.R., Staff College of India and Institute of Management, apart from leading tea Scientists. Tocklai has also continued the programme of study leave where research assistants were sent to qualify for post-graduate i.e. Master's and Doctoral, degrees.

Research Infrastructure

During the year 1977-78 Planning Cell and Irrigation Unit have been added. A gas liquid chromatograph, a spectrophotometer, a drip-irrigation system and subsoil drainage equipment and a growth cabinet are major new items added to the existing research facilities. Atomic absorption spectrophotometer, U.V. spectrophotometer, automatic titration outfit, compactor, high speed centrifuge are other major equipment which were purchased early in 1977 and were installed early in this financial year.

To streamline the construction of laboratory buildings and residential houses at Tocklai and its Sub-Stations, future needs have been visualised and a preliminary master plan has been prepared. In accordance with the master plan, construction of residences has been started during the year. Laboratories will soon follow.

Technology transfer

Tocklai held its largest ever biennial conference (28th) during November 1977 where some 176 delegates attended and 24 research papers were presented on recent research findings by Tocklai's scientists to the users of research. These researches were discussed thoroughly with the planters and the scientists over three days of deliberations.

Advisory services have been considerably strengthened with the joining of three new Advisory/Asst. Advisory Officers.

A large number of enquiries have been received for growing tea in non-conventional areas *viz.* Arunachal, Nagaland, Meghalaya, Manipur, Mizoram.

Training of field personnel is a major plank of the transfer of technology in a highly organised and sophisticated industry like tea. One-year Tocklai course for junior tea estate executives has been reintroduced this February. Two short term refresher courses in Agricultural Economics were introduced for the first time. Again for the first time, at these courses senior planters and executives shared their experience with the courses by delivering lectures and by serving on its faculty discussion panels. One-day Orientation courses in the methods of work study were also undertaken to initiate motion and time studies in 8 gardens for the first time. These courses were in addition to the two field management courses reintroduced last year, the usual three drainage courses continuing for a decade and two V. P. training courses. As many as 250 trainees from various cadres of the industry participated in a total of 13 in-job/refresher trainings and courses at Tocklai.

Research results

Reports of individual departments follow. In these are given highlights and details of research findings which the readers will find to be most interesting. New areas of work have been investigated, old results reviewed and new horizons cited. We hope to continue this trend in the years to come

ORGANISATION

On the 31st March 1978, the Senior Staff consisted of :—

Director
Dr. N. K. Jain, M.Sc. Ag. (B.H.U.), Ph.D. (Illinois)

Adviser
Dr. D. N. Barua, B.Sc. (Calcutta), Ph.D. (Cantab)

Assistant Planning Officer
Mr. S. Acharya, B.Sc. (Agril Engg. & Tech.), M.Tech (Ind. Mgt) (IIT Kharagpur)

Administration :
Administrative Officer
Gr. Capt. (Retd.) K. R. Gopalan

Assistant Administrative Officer
Mr. B. S. Kotoky, B.A., LL.B. (Dibrugarh)

Accounts :
Accounts Officer
Mr. S. Mazumdar, B.Com., (Calcutta),A.C.A.

Maintenance :
Station Engineer
Mr. G. B. Singh, A.M.I.S.E.

Medical :
Medical Officer
Dr. (Major) S. W. Rohman, M.B.B.S.

Library & Publication :
Librarian and Assistant Publication and Information Officer
Mr. J. N. Sharma, M.A. (Gauhati)

Soils & Meteorology :
Tocklai :
Head
Mr. S. K. Dey, B.Sc. (Calcutta), Assoc, I.A.R.I.

Second Soil Scientist
Dr. B. Singh, B. Tech (Pant Nagar), M.Tech (I.A.R.I.), Ph.D. (London)

Assistant Soil Scientist
Mr. N. G. Bhattacharjee, B.Sc. (Calcutta)

West Bengal :
Assistant Soil Scientist
Mr. A. K. Sengupta, B.Sc. (Hons.) (Calcutta)

Botany :
Head
Dr. H. P. Bezbaruah, M.Sc., Ph.D. (Gauhati)

Plant Physiologist
Dr. P. N. Rustagi, M.Sc., Ph.D. (Delhi)

Assistant Plant Physiologists
Mr. B. N. Gogoi, B.Sc. (Gauhati)
Dr. L. Manivel, M.Sc.Ag. (Madras), Ph.D. (California)

Agronomy :
Head
Dr. F. Rahman, M.Sc.Ag. (Bihar), Ph.D. (I.A.R.I.)

Second Agronomist (Weed Control)
Dr. V. S. Rao, M.Sc.Ag. (Osmania), Ph.D. (Cornell)

Estate Manager
Mr. A. K. Sahney, B.A. (Delhi)

Entomology :
Head
Dr. B. Banerjee, M.Sc. (Calcutta), M.S. (S. Illinois), Ph.D. (London), F.A.Z., F.R.E.S. (London)

West Bengal :
Assistant Entomologist
Mr. N. S. Sengupta, B.Sc.Ag. (Dacca)

Mycology :
Head
Dr. G. Satyanarayana, B.Sc. (Hons.) (Andhra) Ph.D. (Madras), F.B.S., F.I.P.S.

C.S.I.R. Pool Officer
Dr. M. N. Venkataramanan, M.Sc., Ph.D. (Madras)

Biochemistry :
Assistant Biochemist (Officer-in-charge) ..
Dr. M. R. Ullah, M.Sc., Ph.D. (Gauhati)

Tea Tasting :
West Bengal :
Tea Taster
Mr. R. P. Basu

Tocklai :
Second Tea Taster
Mr. A. K. Das, B.A. (Gauhati)

Engineering Research & Development :
Head.
Mr. T. C. Baruah, B.Sc. (Hons.) (Gauhati), B.Sc. Mech. Eng. (B.H.U.), M.Sc. Mech. Eng. (Manchester)

Statistics :
Head
Mr. A. K. Biswas, M.Sc. (Gauhati)

Agricultural Economics:
Agricultural Economist
Dr. R. C. Awasthi, M.Com., LL.B., Ph.D. (Agra)

Cost Adviser
Mr. N. S. Venkatakrishnan, M.A., LL.B., FICWA

Advisory :
Head
Dr. P. C. Sharma, M.Sc. (B.H.U.), Ph.D. (London), F.L.S.

Advisory Officer
Dr. T. K. Ghosh, B.Sc. (Patna), Assoc. I.A.R.I., Ph.D. (Cornell)

Upper Assam :
Advisory Officer
Mr. J. Chakravartee, M.Sc.Ag. (Gauhati)

Lower Assam :
Advisory Officers
Mr. B. Borthakur, M.Sc.Ag. (Gauhati)
Dr. D. N. Chakravarty, B.Sc.Ag. (B.H.U.), Ph.D. (Moscow)

Assistant Advisory Officers
Mr. R. Dasgupta, M.Sc.Ag. (Bihar)
Dr. S. Basu, M.Sc.Ag., Ph.D. (Calcutta)

Tripura :
Assistant Advisory Officer
Mr. S. C. Dey

North Bank :
Advisory Officer
Mr. S. Basu, B.Sc.Ag. (Hons.) (Delhi), Assoc. I.A.R.I.

Cachar :
Advisory Officer
Mr. S. K. Sarkar, B.Sc. (Calcutta), B.Sc. Ag. (B.H.U.)

West Bengal :
Advisory Officer
Mr. H. Mitra, B.Sc. (Calcutta)

Dooars Terai :
Advisory Officers
Mr. B. C. Barbora, B.Sc.Ag. (Gauhati), M.Sc. Ag. (I.A.R.I.)
Mr. B.C. Phukan, B.Sc. Ag. (Gauhati), A.I.F.C.

Darjeeling :
Advisory Officer
Mr. R. Padmanaban, B.Sc.Ag. (Madras)

SENIOR STAFF MATTERS

Appointment

Dr. P. N. Rustagi joined as Plant Physiologist on 11.7.77.

Mr. S. Acharya joined as Assistant Planning Officer on 26.10.77.

Dr. B. Singh joined as Second Soil Scientist on 27.10.77.

Dr. D. N. Chakravarty joined as Advisory Officer on 14.12.77.

Mr. R. Dasgupta joined as Assistant Advisory Officer on 2.1.78.

Dr. S. Basu joined as Assistant Advisory Officer on 27.2.78.

Transfer

Mr. S. C. Dey, Assistant Advisory Officer has been transferred to Agartala Advisory Centre as Assistant Advisory Officer Tripura on 23.2.78.

Mr. N. S. Sengupta, Assistant Entomologist has been transferred to Dooars Advisory Branch on 1.7.77.

Retirement

Dr. P. C. Sharma, Senior Advisory Officer retired from I.T.A. service on 31st March'78 and joined T.R.A. as Deputy Director.

Resignation

Md. M. Farook Assistant Advisory Officer resigned from Association's service on 19.8.77

TRAINING & COURSES

One Year Training Course

from February '78—8 trainees are attending.

Vegetative Propagation Training course

1st course from 1.4.77 to 30.6.77—5 trainees attended.

2nd course from 1 9.77 to 30.11.77—8 trainees attended.

Short Term Course

from mid September '77 to mid January '78 —4 trainees attended.

Surveying & Drainage Course

1st course from 2.1.78 to 6.1.78 -27 persons attended.

2nd course from 9.1.78 to 13.1.78—28 persons attended.

3rd course from 30.1.78 to 3.2.78—31 persons attended.

Field Management Course

1st course from 21.9.77 to 23.9.77—24 persons attended.

2nd course from 26.9.77 to 28.9.77—28 persons attended.

Orientation course on Motion & Time study

1st course on 2.5.77 -12 persons attended.

2nd course on 19.5.77 —6 persons attended.

Tea Economics Course

1st course from 29.6.77 to 30.6.77— 30 persons attended.

2nd course from 29.7.77 to 30.7.77—31 persons attended.

TOCKLAI BIENNIAL CONFERENCE

Twenty-eight Tocklai Biennial Conference was held from 24th November to 26th November, 1977 and 176 delegates attended the Conference.

WORKSHOP ON R & D MANAGEMENT

A workshop on R & D Management was conducted from 12th to 17th September 1977 for all T.R.A. Officers. Thirty-six Officers attended. This Workshop was organised in collaboration with Management Development Unit (Planning Division), C.S.I.R., New Delhi and had invited faculty members from amongst the Captains of the tea industry, Staff College of India and Institute of Management, New Delhi.

VISITS

The Director visited Calcutta to attend the meetings of Scientific Advisory Committee on 18.4.77 & 24.10.77; TRA Executive Committee meetings on 16.5.77, 12.12.77 & 23.3.78; TRA Annual General meeting on 28.12.77; Council of Management meeting on 29.12.77; Instant Tea Project meeting & Budget discussions from 8.9.77 to 11.9.77; Tea Board's Hill Development Committee meeting, Research Liaison Committee meeting and meeting of the Economic Advisory Committee from 26.9.77 to 1 10.77; Agricultural Sub-committee meeting & Engineering Sub-committee meeting on 30.12.77; Instant Tea Steering Committee meeting & Research Liaison Committee meeting on 28.3.78; Scientific Committee meeting of Indian Plywood Industries Research Institute and their Board of Governors meet on 16.6.77 to 17.6.77 and New Delhi to attend the C.S.I.R. Director's Conference on 20.5.77; C.S.I.R. Governing Body meeting on 20.9.77; C.S.I.R. Society meeting on 23.11.77; Co-ordination Council meeting of Biological Group of Laboratories of C.S.I.R. on 3. 9.77; ISI Pest Control Equipment Committee meeting on 27.4.77 Co-ordination Council Chairmen's meet on 13.2.78 and Shanti Swaroop Bhatnagar Award Committee meeting on 31.1.78. He also visited Darjeeling to attend the Tea Board Meeting for equipment on 17.5.77 and Lucknow for the meeting of Co-ordination Council of Biological Group of Laboratories of C.S.I.R. on 11.2.78 to 12.2.78.

Dr. R. C. Awasthi visited IARI Delhi and G.B. Pant University on 30th December '77 and 5th January '78. He also attended the symposium on Plantations Crops held at Rubber Research Institute. Kottayam, Kerala from 20th to 24th March '78.

Mr R. P. Basu attended three meetings on ASC Specification of Tea for defence services organised by Govt. of India Ministry of Agriculture & Irrigation & Food at Calcutta.

Mr. T. C. Baruah visited Port Engineering Works, Howrah and Calcutta. He also visited Delhi and Bombay to attend ISI Committee meetings.

Dr. B. Banerjee visited Mysore, Lucknow and Delhi in connection with the meeting of the Co-ordination Council of Biological Group of Laboratories C.S.I.R. during 1977 78.

Dr. L. Manivel visited BARC, Bombay; UPASI, Cinchona & SPIC, Tuticorin in Tamilnadu.

Mr. R. Padmanaban attended All India Weed Science Conference at Coimbatore on 3rd & 4th February, 1978.

Dr. F. Rahman visited Kottayam, Kerala to attend symposium on Plantation Crops ; Bangalore to visit Indian Institute of Horticultural Research and University of Agricultural Sciences.

Dr. V. S. Rao visited the American Springs & Pressing Works Ltd., held at Bombay from 19th to 27th December, 1977. He also attended the All India Weed Science Conference organised by the Indian Society of Weed Science at Tamilnadu Agricultural University Coimbatore on 3rd to 4th February, 1978.

Dr. G. Satyanarayana attended the 18th Annual meeting of Association of the microbiologists of India at Madurai.

Dr. B. Singh visited Indian Institute of Technology, Kharagpur in January, 1978.

Dr. M. R. Ullah visited ISI meeting AFDC 39 in UPASI, Cincona from 23rd to 25th February, 1978.

VISITORS

The following scientists, distinguished persons visited Tocklai during the year under review:

Scientists :

Mr. Astika Wenten, Plant Breeder, Tea Research Institute, Bandung, Indonesia.

Mrs. (Dr.) B. E. Glasgow, Former Prof. of Botany, Cornell University, U.S.A.

Mr. Chris Parker, Tropical Weed Specialist, Weed Research Organisation, Oxford, U.K.

Dr. C. S. Venkat Ram, Director, Tea Research Station, UPASI, Cinchona, Tamil Nadu.

Dr. D. J. Hira, PIRA Surrey, England.

Mr. D. W. R. Headford, Sr. Research Officer, ICI Ltd., U. K.

Mr. D. N. Barbora, Technical Manager, Tea-Ma Consortium India Ltd. Calcutta.

Dr. Earnest Hainsworth, Former Director, TRI East Africa.

Mr. Gireesh Singhal, Regional Research Laboratory, Jorhat.

Dr. G. N. Rao, Deputy Director, Tea Research Station, UPASI, Cinchona, Tamil Nadu.

Dr. G. Thyagarajan, Director, Regional Research Laboratory, Jorhat.

Mr. Hari Narain, Director, National Geophysical Research Laboratory, Hyderabad, A.P.

Dr. M. G. Hampton, Engineering Consultant, U.K.

Dr. H. R. Cama, Head, Biological Sciences, Indian Institute of Science, Bangalore.

Mr. H. Hayakama, Agronomist, Japan.

Mr. Harald Klauda, Hamburg.

Mr. H. Fergusan, Tata Finlay Ltd., Calcutta.

Mr. I. J. Panja, Tanzania Tea Authority, East Africa.

Mr. K. G. Mehta, H.P. Agricultural University, Palampur.

Mr. K. K. Mitra, Tea Board, Calcutta.

Dr. M. J. Green, (former Botanist at Tocklai and TRI) Edinburg.

Dr. N. M. Abdul Gaffar, Technologist, Tea Research Institute, Sri Lanka.

Mr. P. C. H. Reece, Chairman, ICI, London.

Dr. P. C. Bora, Tea Husbandry & Technology, Assam Agricultural University, Jorhat.

Dr. P. S. Majumdar, Vice-Chancellor, Assam Agricultural University, Jorhat.

Dr. P. Sivapalan, Head, Entomology & Nematology, Tea Research Institute, Sri Lanka.

Dr. R. Ramanna, Bhabha Atomic Research Centre, Trombay.

Mr. Ravi Ranjan, Regional Research Laboratory, Jorhat.

Mr. R. C. Heldoneth, Rohm & Hass Pacific Region in Philippines.

Dr. R. N. Mitra, Ag. Economist, Duncan Agro Industries, Calcutta.

Dr. R. C. Choudhury, J. Thomas & Co. Pvt. Ltd., Calcutta.

Dr. R. T. Ellis, Director, Tea Research Foundation of Central Africa, Malawi.

Mr. Satoru Hirano, Japan.

Dr. S. Pendlington, Unilever Research, Colworth Laboratory, Unilever Ltd., Bedford, U.K.

Mr. Peter Schroeder, Research Manager, Unilever Research, Bedfordshire, U.K.

Dr. S. R. Barooah, Technical Director, Motilal Pesticides, New Delhi.

Dr. S. H. Choudhury, Director, Bangladesh Tea Research Institute, Srimangal, Sylhet, Bangladesh.

Mr. S. K. Misra, Hoechst Pharmaceuticals Ltd., Calcutta.

Dr. V. Ranganathan, Soil Scientist, Tea Research Station, UPASI, Cinchona, Tamil Nadu.

Dr. Wolfgang Biegel, Technical Director, E. Merck, Germany.

Mr. Yoshiharu Inoue, Japan.

Mr. Masaaki Nakada, College of Agriculture & Veterinary Medicine, Tokyo.

Dr. B. P. Srivastava, Mgr. R & D Centre, Union Carbide India Ltd., Bhopal.

Distinguished persons :

Mr. Abu Abraham, M. P., New Delhi.

Mr. T. S. Broca, Chairman, Tea Board, Calcutta.

Mr. M. W. Butterwick, Chairman, Walter Duncan & Goodrick.

Mr. Hemen Baruah, Member, Council of Management, Jorhat.

Mr. J. P. F. Furst, Tea Trade Technical Pvt. Ltd. Gauhati.

Mr. J. C. Glencross, London.

Mr. E. F. G. Maynard, British Deputy High Commissioner, Calcutta.

Mr. R. K. Puri, Director, Tea Promotion, Tea Board of India, London.

Capt. & Mrs. James W. Reese, U. S. Embassy, New Delhi.

Mr. V. N. V. Padmanabha Rao, Chief Reg. Manager, State Bank of India, Shillong.

Miss. Henry Repoport, University of California, Berkely.

Mr. H. R. Shah, President, Tea Association of India.

Mrs. Senti Aier, Kohima, Nagaland.

Mr. K. S. Bhatnagar, Chief (Finance), C.S.I.R., New Delhi.

Mr. D. Benjamin, McLeod & Co., Ltd.

Mr. John S. M. Botterill, Birmingham, U. K.

Mr. R. Brittain, Shaw Wallace & Co., Calcutta.

Mr. T. R. Chowdhury, Secunderabad.

Mr. K. Emoto, Japan.

Mrs. M. Emoto, Japan.

Mr. C. S. Gandhi, Sudarshan Chemicals, Poona.

Mr. Reet Hazarika, Sheba Travels, Gauhati.

Mr. P. D. Jothikumar, Coimbatore, South India.

Mr. N. M. Karumbaya, Coimbatore, South India.

Mr. Isam Khulusi, Baghdad, Iraq.

Mr. K. Kitamura, Japan.

Mrs. R. Kitamura, Japan.

Dr. Krishna Kalpagam, C/o Merck India (P) Ltd. Bombay.

Mr. M. Lamond, McLeod Russel & Co. Ltd., London.

Mr. R. G. Lennox, C/o Brooke Bond Liebig, Kericho, Kenya.

Mr. M. R. P. Lappan, Munnar, Kerala.

Mrs. Miagawa, Japan.

Mr. D. D. Mowatt, Upper Shillong.

Mr. A. J. W. Monkhouse, Brooke Bond Liebig, Kericho, Kenya.

Mr. K. Nakaya, Japan.

Mr. Hiroyoshi Nakayama, Japan.

Miss Sonia Prodhan, Tea Board, Calcutta.

Mr. Robert C. Preble, Chicago, U.S.A.

Mr. G. T. Ratnagrahi, Calcutta.

Mr. Shibnath Roy, Tea Board, Jorhat.

Miss Padma Raj, Tea Board, Calcutta.

CDR. V. N. Mahhov Rao (Retd.), Hyderabad.

Mr. K. L. Rathi, Sudarshan Chemicals, Poona.

Maj. Gen. K. Chiman Singh, HQ, IGAR, Shillong.

Mr. T. Saito, Japan.

Mrs. Ai Saito, Japan.

Miss H. Shimabukuro, Japan.

Mr. M. Salseem Sheriff, Tata-Finlay Ltd., Tamilnadu.

Mr. Mohamed A. H. El Shanawany, Cairo.

Miss Reetu Tyagi, Tea Board, Calcutta.

Mr. Veseyi Theyo, Kohima Nagaland.

Mr. A. J. R. Vigne, Kericho Kenya.

Mr. A. I. Y. Wright, Republic du Burundi.

Miss Nina Wason, Tea Board, Calcutta.

There was a substantial increase in the membership during 1977-78 and the Advisory Officers had to pay more than 22% extra visits to help the member estates in solving their problem.

Rock phosphate is gradually substituting superphosphate in mature tea. Potash along with nitrogen is becoming regular practice in most estates.

The enthusiasm of very close planting is gradually fading. Most estates are now planting about 16,000 bushes per hectare, while the upper limit in some cases has been 20,000 per hectare.

Attack of looper was severe in the Dooars and South Bank. Thrips, scarlet and purple mites and scale insects caused considerable damage in Darjeeling.

The incidence of blister blight was severe in Darjeeling and it was reported this year for the first time from a number of estates in the Dooars. More estates showed interest in soil fumigation in controlling the primary root diseases. Asco-Lichen (Anthraconthecium meniparensis), *a partial parasite was found for the first time in Darjeeling.*

General

Dr. D. N. Chakrabarty was appointed as Advisory Officer, Mr. R. Dasgupta and Dr. S. Basu were appointed as Assistant Advisory Officers and they were under training.

The following gentlemen were appointed as Field/Research Assistants during the year and after completion of their training posted in different sub-stations as mentioned against their names.

Ajit Kumar Phukan	: South Bank (Tocklai).
Bhaskar Hazarika	: Upper Assam.
Ashok Kumar Bordoloi	: Upper Assam.
Budhindra Deka	: North Bank.
Punya Bharali	: North Bank.
Dipok Chandra Baruah	: North Bank.
Lakshya Kumar Sarma	: North Bank.
Tapash Kr. Bhattacharjee	: Cachar.
Ashit Baran Saha	: West Bengal.
Ashok Kumar Sarkar	: West Bengal.
Subir Dutta	: West Bengal.

Mr. R. B. Singh, Steno-Typist was transferred from Tocklai and posted at Darjeeling vice Sri K. P. Chakravorty also has been transferred to Accounts Department. Mr. H. N. Baruah was transferred to Advisory Department from Botany Department in place of Mr. Singh.

Mr. M. Farook, Assistant Advisory Officer, resigned in August 1977.

Table 2.01. *Details of Advisory visits paid in the member estates during* 1976-77 & 1977-78.

District	No. of visits paid		No. of member estates visited during		Total number of member estates during	
	1976-77	1977-78	1976-77	1977-78	1976-77	1977-78
South Bank	479	595	297	305	312	353
North Bank	223	183	87	77	91	94
Cachar (including Tripura)	154	162	71	76	73	88
Dooars	299	395	106	109	119	125
Terai	69	165	25	36	33	36
Darjeeling (including Sikkim)	112	131	62	68	66	75
Total :	1336	1631	648	671	697	771

The number of advisory visits paid to tea estates in North Bank was less during the period because of the resignation of Assistant advisory officer.

In addition to routine advisory visits, 164 visits were paid to experiments in different parts of North-East India.

Area Scientific Committee Meeting

The number of meetings held in the various districts is given below :

South Bank East	: 4
South Bank Central	: 3
South Bank West	: 3
North Bank East	: 4
North Bank West	: 4
Cachar	: 4
Dooars	: 5
Terai	: 4
Darjeeling	: 3
JASC meeting of all the area : South Bank West	: 1

With the area scientific committee meetings, open sessions in the form of seminar were also held for the planters of the area to discuss the local problems and these were well attended. These meetings and open sessions proved to be very useful for exchanging thoughts and ideas between the planters and the Tocklai Scientists.

Joint Area Scientific Committee Meeting held at Tocklai 4th 6th April, 1978

The main topics of discussion in the joint meeting were achievements in respect of increasing yield in estates located in low rainfall areas, progress made in respect of establishment of young teas, latest thinking and ideas developed in manufacture of tea, problems

and their solutions of planting teas in marginal land, solution of drainage problems, advantage and disadvantage of intensive planting and failure and success with clones. After demonstration in the field the delegates and other planters assembled in an open session and discussed the subjects.

Participants of the joint meeting included senior planters of the North and South India, Tea Research Association and United Planters' Association of South India (UPASI), Scientists and Technologists, delegates of various agency houses and tea companies in Calcutta and Gauhati, representative of Reserve Bank and Agricultural Refinance Corporation, manufacturers of different Agro-chemicals, Tea Brokers and the local planters.

Seminars

The details of the seminars held during 1977-78 are given.

Table 2.02. *Summary of seminar in different area*

Area	Data	Subjects
South Bank East	15 Apr 1977	Agricultural Chemicals
	6 Jun 1977	Engineering & Manufacture
	30 Mar 1978	Replanting & Planting of tea.
South Bank Central	12 Jul 1977	Plant Protection
	12 Aug 1777	Engineering & Manufacture
	9 Dec 1977	Soils, Agriculture & Botany
South Bank West	18 Jul 1977	Soils, Agriculture & Botany
	22 Aug 1977	Weed Control
North Bank East	24 May 1977	Plant Protection
	29 Aug 1977	Engineering & Manufacture
	6 Dec 1977	Soils, Agriculture & Botany
North Bank West	25 May 1977	Plant Protection
	30 Aug 1977	Engineering & Manufacture
	7 Dec 1977	Soils, Agriculture & Botany
Cachar	14 Jun 1977	Plant Protection & Weed Control
Dooars	5-6 May 1977	Special Seminar on Pest Control for Duncan Brothers
	10 May 1977	Weed Control and Plucking
	25 Jul 1977	Plant Protection
Terai	12 May 1977	Weed Control and Plucking
	27 Jul 1977	Plant Protection
	27 Sep 1977	Engineering and Manufacture
Darjeeling	13 May 1977	Weed Control
	29 Jul 1977	Plant Protection

The consensus of the forum was that expeditious steps are called for to increase the productivity of teas. In order to achieve this object the assembly was of the opinion that due care and attention be given not only to young teas but also to old teas which still form about 80% of our tea areas.

Lecture Courses

The following courses were organized at Tocklai

Field Management : 2 Courses (each of 3 days duration)

Surveying & Drainage : 3 Courses (each of 5 days duration)

Operational Research

A number of tea sections in estates under different agroclimatic conditions were selected to identify the limiting factors in yield. Once these factors were identified, current Tocklai recommendations were implemented to the extent required to increase productivity. The progress was monitored by the Advisory Officers.

Advisory Branch Plots

Plots on Advisory branches are maintained for distribution of cuttings of Tocklai released clones and for conducting some trials on Tocklai recommended agricultural practices. In this context, the following has been the progress :

(a) Distribution of Cuttings

The details of distribution of cuttings, generative clones and seeds from various outstations to member estates are given in table 2.03.

Green leaf harvested from plots in different Advisory Branches are stated below:

North Bank : 4,654 kg
Cachar : 6,629 kg
Nagrakata : 37,855 kg

(b) Experiments

The following trials were in progress at Nagrakata Branch plot.

Table 2.03. *Distribution of cuttings, scions, generative clones and seeds from out-stations*

Out-Stations	VP cuttings	Scions	Generative cuttings	Generative Scions	Seed in kg	plants
South Bank	6,83,105	3,556	10,100	840	675 kg	—
North Bank	1,44,260	2,135	—	—	—	—
Cachar	2,19,620	—	—	—	—	—
Dooars & Terai	6,22,184	2,344	31,625	2,500	—	—
Total :	16,69,169	8,536	41,725	3,340	675	—

(i) Long term agricultural trials with different clones.
(ii) New long term trial different clones.
(iii) Nitrogen response to different clones.
(iv) Biclonal stock trial with various Tocklai stocks.

In the North Bank at Namgaon a trial on spacing in a fan shaped design was laid out during autumn of 1977.

Two clones were offered for testing in Nagrakata. These clones were planted during the autumn of 1977.

(c) Clonal Proving Station (Darjeeling)

Two clones, T/78 and T/135, were certified for Darjeeling which brought the total number of clones certified for Darjeeling to nine (Re: Annual Report 1976-77). During the year 1,409 samples were manufactured for evaluation of quality. Trials C & D mentioned in 1976-77 annual report, were handed over to the management of Ging Tea Estate in lieu of new area being made available for the station's future planting. The following *Jats* were planted out during the year.

Nanda Devi (Stock 378) Standard
Tukdah 25
Nagrifarm 27/10
Kopati 1/1
Kopati 1/4
Kopati 6/12
Kopati 12/7
Marybong 23
Marybong 76
Longview 21
Longview 8
Rydak 2

Estate Experiments

These experiments were conducted by this Department in various estates under different agro-climatic regions of North-East India. The objective is to put the initial findings at Tocklai to test in different regions so that in due course of time regional recommendation can be made. At present, 112 experiments are being continued and results of some of the experiments are presented in this report.

The past practice of holding the estate responsible for laying out, imposition of treatments and collection of data has now been discontinued. Instead, trained Tocklai personnels have been directly responsible for each stage of experimentation under the supervision of an officer stationed at Tocklai, who visits the experiments as frequently as possible, and co-ordinates the work with the help of the local advisory officers.

The data are being collected in the newly developed proforma in the field for direct punching and subsequent feeding to the Computers.

The list of experiments conducted by this department is given in Appendix 'A'.

Research & Development Scheme

A scheme on Research & Development was initiated and the details were circulated to all member companies. The main object of this scheme was to carry out need-based experiments on the participating estates under the technical guidance of Tocklai. This should enable the participating estates to derive immediate benefit from the results of such experiments by fruitfully implementing the positive findings on a large scale.

A few estates joined this scheme and Field Assistants were trained at Tocklai to conduct the experiments on the estates in the correct way.

Comments on Agricultural Practices

Land Planning & Drainage

Planters, in general, are becoming more conscious of drainage problems but due to paucity of experienced surveyors, the progress made was not upto expectation. Advisory Officers helped the managers, as and when needed, in laying out drains on the contour survey maps prepared by their appointed surveyors.

The undersized culverts of the railway tracks and the National High-Way with the bed of the culverts often at a higher level caused drainage problems in certain areas.

Sluice gate at Maindrain to check back flow

Pruning Cycle

Inspite of Tocklai's recommendation of 3-yr pruning cycle for vigorous tea and 4-yr cycle for average tea, a certain section of the industry is extending the cycle further by introduction of unprune or other lighter form of skiff. This has led in some cases to incorrect skiffing as well as tipping measures. Cases where very long pruning cycles have been followed, have resulted in considerable thickening of the new wood. Under

Main drain with a bund to check entry of flood water

such circumstances, the normal tipping measure of 20 cm in the light pruned year is not adequate, and a higher tipping measure will have to be given. This, of course, will cause further loss in crop in the pruned year.

Besides, very lengthy pruning cycle causes the problem of bush hygiene.

Rejuvenation

Rejuvenation pruning had not been very popular. However, certain companies having inadequate land for extension planting took up rejuvenation pruning in a planned manner. It was usually observed that the crop loss due to heavy prune could be recovered in the third year after the pruning. Infilling, particularly in blocks has shown very encouraging results.

Plucking

Most estates tried their best to maintain plucking rounds to seven/eight days. The standard of plucking in South Bank was generally satisfactory. However, in the Dooars and Cachar, the standard of plucking was not comparable to that of Assam Valley. Estates who used to tip their teas low appeared to have realised the beneficial effects of leaving adequate maintenance foliage at tipping.

Ground leveling work following medium pruning

Young Tea

The tendency of using a higher bush population over 20,000 per ha has now declined and most estates are using a bush population varying from 14,000 to 20,000 plants per ha. Pegging in combination with low tipping for raising young tea in lieu of the earlier method of centering out and recentering was extensively used and high yield was obtained from pegged tea in the initial years. The standard of management of young teas all over improved considerably.

Planting

Paucity of suitable land for extension planting compelled many estates to go for marginal and submarginal lands. Replanting programmes taken up by the estates were mostly under Tea Board's replanting subsidy

Spacing Trial at H.Q. plot at Thakurbasi-North Bank Ad. Dep.

scheme. Area brought under replacement planting was very small.

Infilling of mature teas gained some attention in South Bank and in the Dooars.

In North Bank infilling was favoured only in case of medium or heavy pruned teas. Block infilling, however, had been done successfully by a number of estates.

Clonal Selection

Clonal selection scheme gained popularity and many estates took up selection work in their old hybrid sections before they are uprooted and lost to the industry for ever. A team of field workers from the Botany Department *were helping the tea estates in their selection works. Advisory Officers also helped the estates with their suggestions.*

Vegetative Propagation

Estates rapidly changed to North light overhead shade in vegetative propagation nursery. Planters in general were happy on the success obtained in propagation under such shade.

Some estates adopted with success direct planting of cuttings on sleeves. Advisory Officers, however, preferred planting on the pre-treating beds and then transfer to sleeves after callusing/rooting as this practice ensures higher percentage of success. The clones propagated in large scale were TV1, TV17, TV18, TV19, Teen Ali 17/1/54 and P-126/A. Estates also have taken interest in propagating the newly released Tocklai clones *viz* TV20, TV21 & TV23. Estates curtailed propagation of TV9 to a great extent.

The progress of vegetative propagation in Darjeeling continued to remain sluggish. Unless the century old tea bushes are replaced quickly, the industry may face a serious situation. Solution to the problem of replanting needs to be found by other authorities *e.g.* Tea Board and State & Central Governments.

Seed

Number of estates which took interest in establishing seed baris with Tocklai biclonal stock 449, 450 & 397 were increased. As these seeds are not easily available for planting, estates having programme of planting with seed used polyclonal stock 203.

Heavy demand for Nanda Devi seed continued from Darjeeling estates. This seed is normally used for infilling vacancies in the existing planting.

Nitrogenous Manure

The tendency of over manuring in mature tea appeared to have declined. Though Tocklai suggests application of manure in a single dose some estates of Cachar applied manure in split doses. Certain groups on South Bank also carried out split application (with what results.....)

Phosphate Manuring

Application of 20 kg phosphate per ha once in three years still continued in mature tea.

Potash Manuring

Potash manuring in mature tea on the basis of soil analysis continued. Potash manuring became popular in West Bengal. Firm recommendation of potash manuring for the Dooars is still awaited.

A huge extension Programme at Doolo T.E (Cachar) target 80 ha per year

Foliar Application of Urea & Zinc

Contrary to Tocklai's suggestions to limit foliar spraying of urea or muriate of potash in waterlogged sections or in drought in early part of the year, many estates are applying these chemicals as a standard practice with the hope of getting some extra crop.

Spraying of Micronutrients

Final recommendation on the results of the micronutrient trials are still awaited, but tea estates are trying micronutrients on their own initiative in the hope of getting some beneficial effect in the year of high prices. A large number of proprietory brands are in the market and some of them have sold large quantities of their micronutrient mixtures.

Manuring of Young Tea

Liberal manuring of young tea with 2:1:2 or 2:1:3 NPK mixture continued all over. Results of new experiments to find out optimum requirement of manure in the context of the new method of raising young tea are awaited.

Weed Control

The problems of controlling resistant weeds like *Polygonum chinense, Diascoria bablifera, Ipomea cymosa, Setaria palmifolia* and *Digitaria sanquinalis* have become more acute. Estates took up manual uprooting and disposal

of such weeds. Mikania was successfully controlled by application of 2,4-D. Area under chemical weed control appeared to increase, mostly using Gramoxone, 2,4-D and Dalapon.

Mulching

Mulching particularly in young teas was widely adopted, but inadequacy of mulching materials had been a problem all over. Some gardens used slow decomposing materials like paddy straw treating it with either sulphate of ammonia or urea at 20 kg N/ha. Some gardens reported excellent results by using mulching against drought effect.

Shade

The unfavourable shade trees like *Albizzia procera* (Koroi), *Dalbergia assamica* (Bormedelua), *Dalbergia sissoo* are being gradually replaced. In the Dooars even though the need of shade is great, planting of shade in poorly shaded sections was not given due importance.

In Darjeeling *Sesbania sinerescence*, a temporary shade species was found to be very encouraging at elevations below 1200 m.

Pests Control

Incidence of pests were low in North Bank, South Bank and in the Dooars. In Cachar pest infestation was comparatively lesser than that in the previous year. In Darjeeling attack of Thrips, Scarlet mite, Purple mite and Scale insect caused considerable damage. Attack of looper caterpillar was severe in some estates of South Bank and West Bengal.

Diseases Control

Major diseases as usual were red rust and black rot. Incidence of black rot in South Bank was lower than in the previous year. The attack of blister blight was severe in Darjeeling, and in some estates of North Bank. For the first time attack of blister blight was reported by a number of gardens of West Bengal. Amongst primary root diseases attack of charcoal stump rot and brown root rot very common.

Red root rot was also reported from a very few estates of South Bank.

Root splitting disease *Armillaria mellea* was recorded for the first time in an estate of Darjeeling. Last year it was first reported from Sikkim where large areas have been affected by the disease.

Estates, in general, took control measures sincerely against the attack of diseases. Control measure taken by the Tripura estates were not adequate.

Soil fumigants gave encouraging results in controlling primary root diseases, but their use remained restricted due to their non-availability in the market.

Appearance of a partial parasite Asco-Lichen (*Anthraconthecium maniparensis*) was found for the first time in Darjeeling. This parasite causes die-back of branches is widely prevalent in higher altitudes. Removal of affected branches is the only method of control.

Die-back of bushes in Darjeeling without showing any symptoms of any known cause warrents a thorough investigation.

Summary of Results

Foliar application of zinc sulphate increased yield in all regions. Indications are available that 12.5 kg/ha may be equally efficient to higher rates except in Darjeeling and North Bank where higher rates may be even better.

Rejuvenation pruning during rains didn't show promise.

Except in odd cases, no extra advantage over infilling at double the number of plants per vacancy plus one was obtained by inter planting in cold weather rejuvenated plots.

Preliminary results of NPK trials showed that high application of nitrogen (200 kg/ha) with suitable combination of phosphate and potash increased the yield of tea in all areas except North Bank and Cachar. Balanced NPK fertilizer is necessary in mature tea for maximisation of yield.

(a) **Foliar Application of Zinc**

(1) **Assam, South Bank Experiments (Nos. As. 109, As. 112, As. 115 & As. 121)**

Four experiments, one each at Panitola (As. 109), Sepon (As. 112), Daimukhia (As. 115) and Bokakhat (As. 121) Tea Estates were conducted in the South Bank. The results are presented in table 2.04.

Table 2.04. *Yield of made tea in kg/ha*

Treatments \ Experiment Nos.	As. 109	As. 112	As. 115	As. 121	Average
T.1 – No. zinc (control	2402	2050	3156	2021	2407
T.2 – 12.5 kg zinc /ha	2386	2117	3441	2307	2563
T.3 –25 kg zinc/ha	2413	2171	3166	2574	2581
T.4 –50 kg zinc/ha	2419	2436	3330	2343	2657
LSD (P – .05)	NS	172	NS	156	
C.V.%	4.21	5.55	5.39	4.78	

Substantial increase in crop due to spraying of zinc sulphate was recorded in three out of four trial plots this year.

At Sepon T.E. (As. 112) progressive increase in crop with increasing rates of zinc sulphate was observed and 50 kg $ZnSO_4$ per ha significantly out yielded all other treatments.

At Daimukhia T.E. (As. 115), however, maximum increase was obtained with 12.5 kg $ZnSO_4$ per ha.

At Bokakhat T.E. yield response was parabolic in nature where maximum yield was obtained with 25 kg $ZnSO_4$ per ha and then it dropped with higher rate.

In the south bank, the average response of zinc during the year showed definite increase due to zinc application over control.

(ii) **Dooars (Experiment Nos. D. 52, D. 53 & D.54)**

Three experiment were conducted in the Dooars one each in Kartick (D. 52), Baradighi (D. 53) and Bhogotpore (D. 54) TEs. The results of 1977, are presented in table 2.02.

Table 2.02. *Yield of made tea in kg/ha*

Treatments \ Experiment Nos.	D.52	D.53	D.54	Average
T.1 – No zinc (control)	3788	3951	2144	3294
T.2 – 12.5 kg zinc/ha	4426	3529	2162	3372
T.3 – 25 kg zinc/ha	4044	3658	2189	3297
T.4 – 50 kg zinc/ha	4043	3267	2299	3203
LSD (P .05)	NS	NS	62	
C.V.%	8.92	10.53	2.21	

In Dooars the response of zinc spraying was parabolic at Kartick T.E. (D.52) with substantial gain due to 12.5 kg zinc sulphate per ha. At Bhogotpore (D.54), however, the trend was linear upto the highest dose of zinc sulphate (50 kg/ha).

(iii) **Darjeeling (Dj. 32 & Dj. 33)**

Two experiments, one each in Arya (Dj. 32) and Sungma (Dj. 33) Tea Estates were conducted in Darjeeling, the results of which were presented in table 2.05.

Table 2·05. *Yield of made tea in kg/ha*

Treatments \ Experiment Nos.	Dj.32	Dj.33	Average
T.1 – No zinc (control)	495	1103	799
T.2 – 12.5 kg zinc/ha	539	1140	840
T.3 – 25 kg zinc/ha	483	1016	750
T.4 – 50 kg zinc/ha	585	1302	944
LSD (P – .05)	NS	172	
C.V.%	11.66	10.71	

Beneficial effect of spraying 50 kg zinc sulphate was observed at both the plots at Arya T.E. (Dj.32) and Sungma T.E. (Dj. 33) in Darjeeling. While the yield increase from 50 kg was significant over all other treatments at Sungma T.E. it was no so at Arya T.E.

(b) **Rejuvenation Experiments**

(i) **Assam, South Bank (Expt. Nos. As.128, As.130)**

Two experiments, one each in Tara (As. 128) and Teloijan (As. 130) TEs were laid out during 1974, the results for 1977 are presented in table 2.06.

At Tara TE As. 128, T3 significantly out yielded all other treatments while at Teloijan TE (As. 130) cold weather pruning was superior to rains pruning but the same could not yield better than control as the infills have not yet contributed fully towards higher production.

(ii) **Dooars, West Bengal (Expt. Nos. D. 43, D. 44, D. 45, D. 46 & D. 47)**

Five experiments, one each in Dalgaon (D.43), Matelli (D.44), Killcott (D.45), Rydak (D.46) and Kumlai

Table 2.06. *Yield of made tea in kg/ha for the year 1977*

Treatments	As.128	As.130
T.1 – No rejuvenation (control)	2052	2924
T.2 – Cold weather prune and infill in the spring with a vigorous clone at double the number of plants per vacancy plus one.	2312	2395
T.3 – Cold weather prune and infill in the spring with a vigorous clone at double the number of plants per vacancy plus one and also interplant to make into hedge i.e. if the original planting was 150 cm × 150 cm, make it into 150 cm × 75 cm.	2523	2363
T.4 – prune in July/August and infill in the autumn as in T2	2240	2195
T.5 – Prune in July/August and infill in the autumn as in T3	2175	2053
LSD (P = .05)	232	194
C.V.%	7.29	5.77

(D.47) TEs were laid out during 1972. The results are presented in Table 2.07.

Table 2.07. *Made tea in kg/ha for the year 1977*

Treatments	D.43	D.44	D.45	D.46	D.47
T.1 – No rejuvenation (control)	1258	1715	2535	1793	1505
T.2 – Cold weather prune and infill in the spring with a vigorous clone at double the number of plants per vacancy plus one.	1293	1735	2485	1806	1916
T.3 – Cold weather prune and infill in the spring with a vigorous clone at double the number of plants per vacancy plus one and also interplant to make into hedge i.e. if the original planting was 150 cm × 150 cm, make it into 150 cm × 75 cm.	1768	1714	2342	1817	1826
T.4 – Prune in July/August and infill in the autumn as in T2.	1172	1650	2164	1430	1560
T.5 – Prune in July/August and in the autumn as in T3.	1434	1876	2338	1836	1832
LSD (P = .05)	226	125	67	184	170
C.V.%	11.59	5.12	2.02	7.52	6.99

Higher yields were obtained from cold weather pruning over rains pruning at all places in the Dooars. All except one experiment at Dalgaon TE (D.43) showed that when the bushes was pruned during cold weather no extra advantage from interplanting was obtained over infilling. On the contrary, when the bushes were pruned during the rains, interplanting was more beneficial at all places except Matelli TE (D.44). It was interesting to note that rejuvenation pruning during the rains proved so deleterious in the Dooars that even after five years these plots could not yield more than control plots inspite of infilling.

(iii) **Darjeeling Experiment (Dj.38)**

One experiment in Bannockburn TE (Dj.38) was continued during 1977. The results are presented in the table 2.08.

Table 2.08. *Yield of made tea in kg/ha*

Treatments	Dj.38
T.1 – No rejuvenation (control)	1141
T.2 – Cold weather prune and infill in the spring with vigorous clone at double the number of plants per vacancy plus one.	893
T.3 – Cold weather prune and infill in the spring with a vigorous clone at double the number of plants per vacancy plus one and also interplant to make into hedge i.e. if the original planting was 150 cm × 150 cm, make it into 150 cm × 75 cm.	804
T.4 – Prune in July/August and infill in the autumn as in T2.	756
T.5 – Prune in July/August and infill in the autumn as in T3.	686
L.S.D. (P .05)	77
C. V.%	7.46

The results showed that cold weather pruning produced significant increase in yield over July/August pruning. Interplanting had not yet shown any advantage.

(c) **Infilling Experiments**

(a) **Assam Experiment (No. As. 129)**

The results of one experiment on infilling As. 129 at Halmari TE for 1977 are presented in table 2.09

Table 2.09. *Yield of made tea in kg/ha*

Treatments	As.129
T.1 – No infilling	1988
T.2 – Infilling with seedling at one plant per vacancy	1918
T.3 – Infilling with clone TV9 at one plant per vacancy	1933
T.4 – Infilling with seedlings in a hedge i.e. double the number of plants per vacancy plus one.	2056
T.5 – Infilling with clone TV9 in a hedge i.e. double the number of plants per vacancy plus one.	2023
LSD (P = .05)	82
C.V. %	2.94

At Halmari TE (As. 129) infilling at one plant per vacancy has not produced any gain so far but infilling at double the number of plants plus one per vacancy added extra yield over other treatments including control.

(b) **Dooars Experiments (D.37, D.40 & D.41)**

Three experiments in the Dooars, one each in Fagu (D.37), Jainti (D.40) and Kartick (D.41) TEs were laid out during 1969, the results of which are presented in the table 2.10.

Table 2.10. *Yield of made tea in kg/ha 1977.*

Treatments	D.37	D.40	D.41
T.1 – No infilling	1824	2042	1655
T.2 – Infilling with seedling at one plant per vacancy	1946	2033	2287
T.3 – Infilling with clone TV9 at 1 plant per vacancy	1934	2288	2246
T.4 – Infilling with seedlings in a hedge i.e. double the number of plants per vacancy plus one	1923	2325	2005
T.5 – Infilling with clone TV9 in a hedge i.e. double the number of plants per vacancy plus one.	2146	2198	2469
LSD (P=.05)	NS	NS	223
C.V.%	11.25	8.14	7.41

In the Dooars experiments infilling with double the number of plants plus one using TV9 clone produced substantial gain in crop over all other treatment at Fagu (D. 37) and Kartick (D.41) while the difference in yield at Kartick (D.41) was significant it had not reached the level of significance at Fagu (D.37).

(d) Nitrogenous Manuring Experiment in Dooars at Baradighi TE (D.33)

This experiment was started in 1966 in the Dooars on sandy loam soil to study the effect of the frequency of application of different levels of sulphate of ammonia on the growth and yield of tea. The experiment was, modified in 1970 when two levels of potash *viz* 0 kg and 200 kg K_2O/ha were also incorporated. The results for 1977 are presented in table 2.11.

Table 2.11. *Yield of made tea in kg ha 1977*

	Treatments	K_0	K_{200}	Mean
T.1	No nitrogen	3151	2973	3062
T.2	110 kg N/ha in one application	3376	3096	3236
T.3	220 kg N/ha in one application	2981	2901	2942
T.4	110 kg N/ha in two equal applications	2964	3425	3195
T.5	220 kg N/ha in two equal applications	3008	3180	3094
T.6	110 kg N/ha in 4 equal applications	2850	3027	2938
T.7	220 kg N/ha in 4 equal applications	2997	3480	3239
T.8	220 kg N/ha in 8 equal applications	3179	3706	3443
Mean	.....	3064	3224	
LSD (P .05)	for main plot Tr	NS		
	for sub plot Tr	NS		
C.V. %	10.91			

In absence of potash application 110 kg N per ha in one application was sufficient to produce maximum yield during 1977. When 200 kg potash per ha was added, the gain in yield from 220 kg nitrogen per ha was clear only when the amount was applied in four or eight splits. Moreover, the beneficial effect of high potash application compared to no potash in combination with 110 kg nitrogen per ha was observed when the bushes received the nitrogen in two or four equal applications, the former being better than the latter.

(e) Cultivation Experiment (As.134)

One experiment in the South Bank at Deohall TE, Hattimara Division (As.134) was initiated in 1975, to compare the effects of various methods of cultivation and chemical weed control in a heavy soil.

The results of 1977 are presented in the table 2.12.

Table 2.12. *Yield of made tea in kg/ha 1977*

Treatments	Yield
T.1 – Check (chemical weed control)	1187
T.2 – One deep hoe in June	1137
T.3 – One deep hoe in December	1212
T.4 – One deep hoe in June + One deep hoe in December	1287
T.5 – One fork hoe in June	1162
T.6 – One fork hoe in December	1232
T.7 – One fork hoe in June + One fork hoe in December	1290
T.8 – Sickling at intervals through out the year	1045
L.S.D. (P – .05)	116
C.V. %	6.57

Some increase in yield was obtained when deep or fork hoeing were done during June and December but this increase was not significant over control. Disturbance of the soil in June either by deep or fork hoeing appeared to affect the yield adversely, but similar treatments during cold weather tended to increase the yield when the weeds were controlled by herbicides only. None of the yield differences were significant.

(f) Pruning Cycle Experiment (Dj.27)

All the pruning cycles were completed in 1977 and complete analysis of the data is in progress. Treatment yield for the year 1977 are presented in table 2.13.

Table 2.13. *Yield of made tea in kg/ha*

	Treatments	Yield
T.1	LP-Lvs-LS	1404
T.2	LP-Lvs-MS	999
T.3	LP-Lvs-DS	980
T.4	LP-Lvs-LS-Lvs	1331
T.5	LP-Lvs-MS-Lvs	1505
T.6	LP-Lvs-DS-Lvs	1639
T.7	LP-Lvs-LS-Lvs-LS-Lvs	1296
T.8	LP-Lvs-MS-Lvs-MS-Lvs	1789
T.9	LP-Lvs-DS-Lvs-DS-Lvs	1513
T.10	LP-Lvs-Lvs-MS-Lvs-Lvs	1262
T.11	LP-Lvs-Lvs-DS-Lvs-Lvs	1698
T.12	LP-Lvs-LS-DS-LS-LS	1661
LSD (P .05)		333
C.V. %		16.24

Amongst the three year cycle T1 (LP-Lvs-Ls) produced significantly higher yield over T2 (LP-Lvs-MS) and T3 (LP-Lvs-DS).

Amongst the 4 year cycle treatments, there was no significant difference between the various treatments in 1977.

Out of the various 6 year cycle treatments T8 (LP-Lvs-MS-Lvs-MS-Lvs) produced significantly higher yield over T7 (LP-Lvs-LS-Lvs-LS-Lvs) and T10 (LP-Lvs-Lvs-MS-Lvs-Lvs).

A clear picture is likely to emerge when the combined analysis of the results of all the years are completed.

NPK Trials

Fourteen new NPK trials were initiated in 1973 in different agroclimatic conditions (including Upper and mid Assam, North Bank, Cachar, Dooars, Terai and Darjeeling) to study the following.

(1) NPK interaction in a single experiment.
(2) Optimum conditions of NP & K fertilizers.
(3) Partial substitution rates of the nutrients through study of response surfaces.
(4) Regional response variation to fertilizer application.
(5) Soil test crop correlation.

The maximum and minimum levels of NP & K were

N = 0 to 200 kg/ha
P = 0 to 100 kg/ha
K = 0 to 150 kg/ha

The experimental sites were under three year pruning cycle like LP-DS-LS except Darjeeling where LP-Lvs-Lvs cycle was followed. The experiments completed one pruning cycle in 1976. Results of combined analysis of the data collected during these three years can be summarised as stated below.

(1) Nitrogen response was observed to the maximum dose of nitrogen (200kg/ha) with a suitable combination of phosphate and potash in all parts of North-East India except North Bank and Cachar where the maximum response was limited to only 100 kg/ha.

(2) The response to higher dose of phosphate had been found to be positive with suitable levels of nitrogen and potash. In all the regions tea in North-East India responded to application of phosphate.

(3) Response to potash application was observed in most areas of North-East India the effect was positive even in Dooars, Terai and Darjeeling when combined in the suitable levels of nitrogen. Potash response is always obtainable in presence of N, but without N it may be small or counter productive.

(4) Results indicate the need of balanced NPK fertilizers for mature tea.

Shade in relation to level of tea Nutrition

Nine experiments (two experiments are now discontinued) were initiated during 1973 in different agro-climatic conditions of North-East India, (3 in South Bank, 2 in North Bank, 2 in Cachar and 2 in the Dooars) to:

(1) compare the yield of tea under different shade regimes.

(2) determine the different response to NPK under varying shade regimes.

Treatment imposed are :

Main plot :

M1 = No shade
M2 = Shade corrected by lopping
M3 = Existing shade (on the heavy shade)

Sub-Plot :

N1 = NPK at 100:20:40 kg/ha
N2 = NPK at 150:30:60 kg/ha
N3 = NPK at 200: 40: 80 kg/ha
N4 = N only at 200 kg/ha

The experimental sites were under LP-DS-LS cycle.

Results

Results indicate that :

(1) Complete removal of shade is not beneficial in any of the regions of North-East India.

(2) Optimum shade status for tea growing may vary from one region to another in North-East India.

(3) Correction of shade by lopping tends to increase the yield in Upper and mid Assam, Cachar and North Bank except where the existing canopy, as in case of Dooars was alright.

(4) Indications are there that optimum shade density will vary for different agro-climatic regions of North East India as there are variations of temperature, sunshine hours and evaporation in these regions.

Yield increased with increase in bush population upto a certain level which shifted back with advance in age and beyond which yield declined. Very high population density reduced root depth in young tea. Cessation/reduction of the dose of nitrogen caused reduction in the yield of well shaded tea in the second year. Application of potassium increased nitrogen response. Drip Irrigation increased early crop. In young tea, effective weed control for six months every year between April and September resulted in better bush frame, growth and yield. In a seven-year old clonal tea, control of a severe infestation of Imperata cylindrica by glyphosate gave 80 per cent increase in yield. Chemical control of mixed weeds resulted in 12 to 24 per cent yield increase over no weed control in youngish mature tea. Imperata cylindrica had inhibitory effect on the germination and growth of Borreria hispida.

Planting and spacing

A new experiment (B.32.2) adopting the systematic fan design covering 23 spacings ranging from 15 cm to 150 cm was planted in July 1974. Details are given in last year's annual report. The 1976 yield data were represented in the form of an asymptotic curvein the above report. Further examination of the data suggested that the yield estimates from the closer spacings

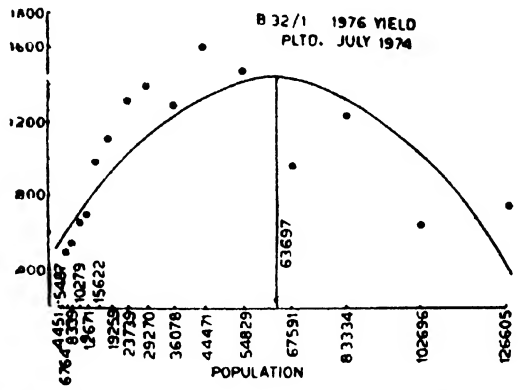


Fig 3.01. Yield population curve showing parabolic relationship in the fan design experiment

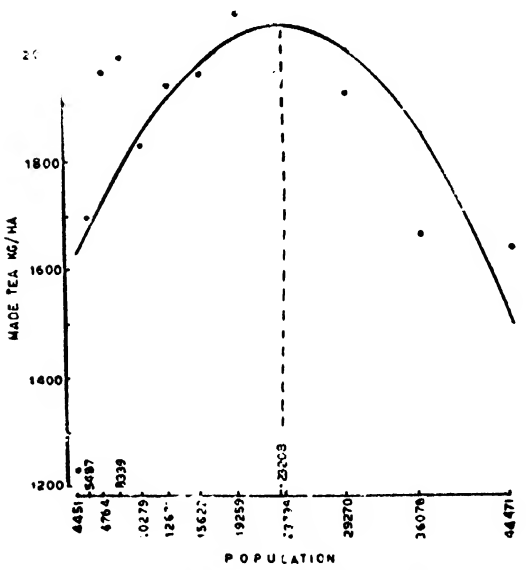
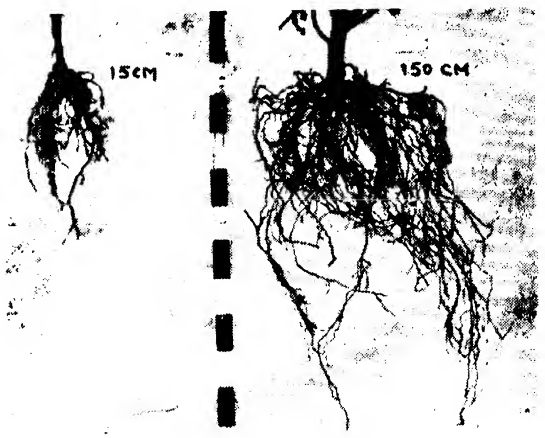
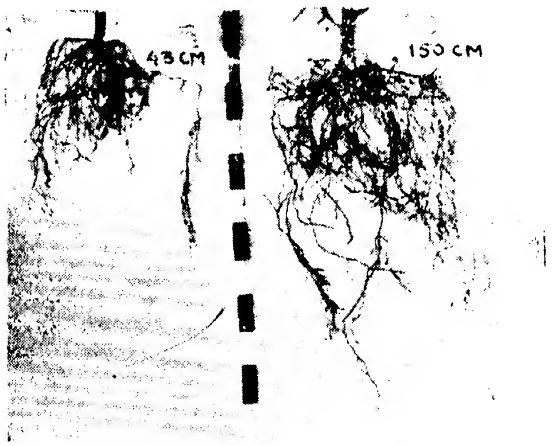


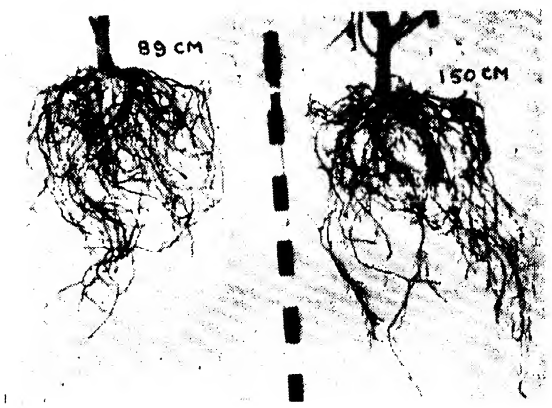
Fig 3.02. Yield population curve showing parabolic relationship in 1977 in the fan design experiment



Root Growth at 15 cm and 150 cm spacing



Root growth at 43 cm and 150 cm spacing



Root growth at 89 cm and 150 cm spacings

Fig 3.03. Root growth at various spacings

tended to get exaggerated as a result of the very small plot size. It also appeared that the number of bushes per plot (11 bushes) was inadequate. It was, therefore, decided to fit the curve eliminating seven close spacings in 1976 and 11 close spacings in 1977 and this gave a parabolic yield population curve with yield declining beyond 63,697 in 1976 and 23,208 in 1977.

The various root growth parameters like spread volume, depth and weight per plant were adversely affected by increasing population. Fig. 3.03.

The angle made by the first and second branch with the main stem was more acute with closer spacings.

Population had a significant effect on microclimate. Relative humidity was highest in the closest spacing and lowest in the widest spacing. Soil temperature was 1°C to 4°C higher in the widest spacing compared to the closest spacing. Soil moisture in the 0 - 60 cm profile was less in the closer spacings compared to the wider spacings.

Plucking

In 1976, the plucking experiment (B.112.1) was modified to study the effect of continuous and intermittent standard and black plucking systems. The plucking season was divided into three periods i.e., beginning of the season to May, June to September, and October to November. Standard and/or black plucking in these three periods was done continuously or intermittently in various combinations. Results so far indicated that there was no significant difference in yield between these treatments in 1976 and 1977. The experiment is being continued.

Plant Nutrition

Several experiments are being conducted at Borbhetta to study the response of tea to different plant nutrients. The results of some of these experiments are breifly discussed below.

Nitrogen

In a factorial experiment (B. 8/1), started in 1966, three nitrogen levels (100, 200, and 300 kg/ha) were included along with four spacings and two clones (TV1. and TV9). There was no yield difference between treatments in 1970. However, in 1971 and 1972, there was no significant difference between 200 and 300 kg, but both these levels were significantly superior to 100 kg level. From 1973, 300 kg level depressed the yield and this effect was significant over 100 kg and 200 kg levels since 1974 (Table 3.01). Yield reduction due to 300 kg N application over 100 kg level was 13, 17, 18, 43, and 53 per cent in 1973, 1974, 1975, 1976, and 1977 respectively. This adverse effect of continuous appli cation of high dose of nitrogen was also observed in case of 200 kg level in 1976 and 1977, the reduction in yield being 17 per cent and 22 per cent respectively. In both these years, 100 kg level was significantly superior to the two higher levels of nitrogen.

Table 3.01. *Effect of different levels of nitrogen on yield (made tea, kg/ha)*

Nitrogen (kg/ha)	1973 L.P.	1974 D.S.	1975 M.S.	1976 L.P.	1977 D.S.
100	1484	1990	1897	1964	1672
200	1544	2060	2028	1633	1305
300	1289	1659	1565	1125	784
L.S.D. (5% Level)	N. S.	226	200	184	199
C.V (%)	22.1	16.1	14.0	16.0	21.6

In a different experiment (B. 104), the effect of three levels of nitrogen (90, 135, and 180 kg/ha) on two *jats* of tea (Betjan and Gaurishankar) planted at five different spacings is being studied. After an initial boost in yield in 1961 and no increase from 1962 to 1968, the higher levels of nitrogen depressed the yield since 1969. The results of 1972 to 1977 (Table 3.02) showed that 90 kg level of nitrogen gave significantly higher yield

Table 3.02. *Effect of three levels of nitrogen on yield (made tea kg/ha)*

Nitrogen (kg/ha)	1972 L.P.	1973 D.S.	1974 M.S.	1975 M.P.	1976 U.P.	1977 L.P.
90	1462	1289	1361	596	1875	1289
135	1370	1174	1343	540	1764	1234
180	1276	1117	1251	481	1591	1133
L.S.D (5% level)	59	50	56	31	87	62
C.V. (%)	9.6	9.4	9.6	13.0	11.1	11.4

than 135 and 180 kg levels in all years except 1974 and 1977 when 90 kg and 135 kg levels were at par. In all the years, application of 180 kg nitrogen reduced the yield significantly.

In another factorial experiment under unshaded condition (B. 5.1), the response of Tingamira jat tea to four levels of nitrogen, two levels of phosphate and two levels of potash is being studied since 1961. The results indicated that 150 kg/ha level depressed the yield (Table 3·03). There was significant reduction in yield when nitrogen level was increased from 50 to 100 kg in 1972, 1973 and 1977.

Table 3.03. *Effect of four levels of nitrogen on yield of unshaded tea (made tea kg/ha)*

Nitrogen (kg/ha)	1972 L.P.	1973 U.P.	1974 U.P.	1975 L.P.	1976 U.P.	1977 D.S.
0	1134	1153	1234	798	1353	993
50	1348	1522	1765	1160	2076	1372
100	1148	1434	1808	2093	2091	1274
150	854	1135	1549	819	1786	1001
L.S.D. (5% level)	87	88	109	88	145	95
C.V.(%)	10.9	9.4	9.6	12.7	11.2	10.5

Effect of cessation/reduction of nitrogen

In an experiment (B.113.1) where single vs split application was being studied from 1965 to 1975 no significant difference between treatments was observed. The treatments were modified in 1976 as per details shown

in Table 3.04. The tea is of Khorijan jat planted in 1960 and has a good stand of *Albizzia odoratissima*.

Table 3.04. *Effect of cessation/reduction of nitrogen (made tea kg/ha)*

Nitrogen dose upto 1975 kg/ka	Nitrogen dose from 1976	Made tea kg/ha 1976 L.P.	1977 D. S.
90 single	90 single	1665	1964
135 single	135 ,,	1538	1909
90 two splits	45 ,,	1552	1770
135 single	45 ,,	1530	1693
135 three splits	90 ,,	1530	1754
90 four splits	No nitrogen	1478	1571
135 four splits	No nitrogen	1522	1553
L.S.D. (5% level)		N.S.	204
C.V.(%)		4.5	6.6

The results of 1976 showed that there was no significant reduction in yield as a result of withholding nitrogen application or reducing the dose of nitrogen. In 1977 cessation of nitrogen caused about 20 per cent reduction in yield. Reduction of nitrogen doses also caused reduction in yield. It is interesting to note that when nitrogen dose was reduced from 135 kg/ha to 90 kg/ha it gave lower yield than when the level was maintained at 90 kg/ha.

Phosphorus

One factorial experiment (B.105) is being conducted since 1960 to study the response of TV 2 clone to four levels of P_2O_5 applied as single superphosphate. After an initial adverse effect at 180 kg till 1970 and no significant response from 1971 to 1973, phosphorus was found to increase yield significantly in 1974, 1976 and 1977 (Table 3.05). There was significant response at 90 kg in 1974 and 1976, and at 45 kg and 90 kg in 1977. There was no significant increase in yield over 45 kg level in 1974 and 1977, but in 1976, 90 kg level was significantly superior to 45 kg level. Application of 180 kg tended to be detrimental in all the years except 1976.

Table 3.05. *Effect of different levels of phosphate on yield (made tea kg/ha)*

P_2O_5 (kg/ha)	1973 L.P.	1974 D. S.	1975 L.S.	1976 L.P.	1977 D.S.
0	1697	1865	1786	1022	1348
45	1730	1977	1824	1231	1631
90	1796	2067	1826	1410	1646
180	1706	1975	1711	1446	1599
L.S.D. (5% leve)	N.S.	117	N.S.	139	175
C.V. (%)	8.6	8.4	11.7	15.3	15.8

This response to phosphorus observed in three of the past four years is possibly due to (a) the effect of chemical weed control which eliminates weed competition and encourages production and development of a mass of surface feeder roots and/or (b) the interaction of phosphorus with zinc which is being applied as zinc sulphate since 1970. Further work is needed to test these hypotheses.

In a different experiment (B. 23/3) conducted on Tingamira jat planted in 1971, the effect of mulch and weed control on the response to various levels of phosphorus application is being studied since 1973.

Table 3.06. *Effect of phosphorus, mulch and chemical weed control on yield (made tea kg/ha)*

Treatment	1973 L.P.	1974 D.S.	1975 L.S.	1976 L.P.	1977 D.S.
Phosphorus (kg/ha)					
0	1468	2140	2031	1623	1890
50	1474	2214	2047	1605	1843
100	1463	2186	2048	1588	1852
150	1506	2181	2084	1634	1901
200	1480	2182	2108	1661	1907
L.S.D. (5% level)	N.S.	N.S.	N.S.	N.S.	N.S.
C.V. (%)	8.5	7.0	7.9	6.8	12.7
Mulch					
No mulch	1480	2162	2017	1592	1800
Guatemala mulch	1477	2200	2110	1652	1956
Weed Control					
Cheeling	1483	2173	2036	1584	1823
Chemical weed control	1473	2188	2091	1660	1934
L.S.D. (5% level)	N.S.	N.S.	47	56	63
C.V.(%)	5.6	5.7	5.0	7.6	7.4

There was no significant yield difference between the various levels of phosphorus application, mulching and weed control treatments in 1973 and 1974 (Table 3.07). In 1975, 1976 and 1977 mulching and chemical weed control were significantly superior to no mulching and *cheeling* respectively. In the light pruned year of 1976, the interaction between mulching and weed control was significant suggesting that mulching in *cheeled* plots was beneficial but mulching in herbicide-treated plots did not benefit the mature tea. However, this interaction was not significant in the deep skiffed year of 1977.

Potassium

The response of clonal tea (TV 2) to potassium is being studied since 1960 in an experiment (B.105) involving four levels of K_2O and P_2O_5 (discussed earlier under response to phosphorus)). The data (Table 3.07) indicated that there was significant response even at 45 kg K_2O/ha in the pruned years and the three levels were at par (1973 and 1976), but in the skiffed years (1974, 1975 and 1977) 180 kg/ha gave higher yield than 45 kg/ha.

Table 3.07. *Effect of different levels of K_2O on yield (made tea kg/ha)*

K_2O (kg/ha)	1973 L.P.	1974 D.S.	1975 L.S.	1976 L.P.	1977 D.S.
0	1495	1671	1555	1048	1218
45	1779	1988	1780	1293	1525
90	1803	2054	1880	1349	1687
180	1854	2171	1933	1420	1793
L.S.D. (5% level)	106	117	149	139	175
C.V. (%)	8.6	8.4	11.7	15.3	15.8

There is a general decline in yield over the years which is most likely a clonal effect.

Nitrogen × Potassium Interaction

In the experiment B 5.1, where shade was absent, the interaction between nitrogen and potassium was significant in all the years since 1973 (Table 3.08). The presence of K_2O (100 kg) had significant beneficial effect on the response to nitrogen.

Table 3.08. *Effect of nitrogen in the presence and absence of potassium on yield (made tea kg/ha)*

Potassium levels	1975 (I.P.)		1976 (I.P.)		1977 (D.S.)	
Nitrogen levels	K_0	K_{100}	K_0	K_{100}	K_0	K_{100}
No	783	813	1359	1346	1031	952
N_{50}	1030	1291	1896	2257	1241	1502
N_{100}	882	1303	1720	2462	1058	1490
N_{150}	567	1072	1396	2176	747	1254
L.D.S. (5% level)	124		206		135	
C. V. (%)	12.7		11.2		10.5	

The deleterious effect of high level of nitrogen was greatly reduced in the presence of potash. The levels N_{50} K_{100} and N_{100} K_{100} gave significantly higher yields in all the years.

This interaction was not significant under shade.

Zinc

In one trial (B. 108/1.2), the effect of zinc is being studied since 1970 on Tingamira jat tea planted in 1958 and grown under medium shade. Zinc was applied as zinc sulphate at 24 kg/ha. Except in 1971, no significant response to zinc was observed. This experiment has been discontinued.

In another experiment (B. 1A/2.1) where clonal tea (TV 9) was planted in 1964, a study is being conducted since 1973 to determine the level, method, and frequency of application of zinc on mature tea. Zinc was applied to the foliage or soil at 12.5 and 25.0 kg/ha either once a year or once in three years. No significant yield differences between the treatments were observed so far. This experiment has been discontinued.

Long term yield trial of Tocklai clones

A long term trial (B. 40/1) was initiated in 1966-77 with different clones to compare their yield performance under *Indigofera teysmanii* shade; Yield data (not adjusted for vacancies) are given in Table 3.09. Clone TV 17 gave the highest yield and was at par with clones TV 10, TV18, TV14 and TV11. It is interesting to note that TV19 which gave the highest yield in 1976 ranked 7th in 1977. This suggests the possibility of interaction of clone with type of prune. This aspect will be studied in greater depth in-future.

Table 3.09. *Yield of different clones and seed stocks (made tea kg/ha).*

Clone	Vacancy in per cent	Yield in 1977	Clone	Vacancy in per cent	Yield in 1977
TV 1	12	1960	TV 13	41	2223
TV 2	27	2009	TV 14	16	2703
TV 4	9	2435	TV 15	24	2431
TV 6	44	1740	TV 16	20	2410
TV 7	3	2013	TV 17	10	3028
TV 8	8	2440	TV 18	7	2716
TV 9	4	2270	TV 19	8	2614
TV 10	4	2947	107/2	6	2489
TV 11	4	2679	Stock 450	4	2357
TV 12	10	2654	Betjan	7	2296
L.S.D. (5% level)			380		
C.V.(%)			11.1		

Irrigation

A drip irrigation system was installed in December, 1977 mainly to study the feasibility of drip irrigation in tea. This system, also known as Trickle Irrigation, involves slow application of water to the root zone of the crop. This is done by using PVC tubing along the crop row and small nozzles or emitters are provided near each plant. Water is pumped through the plastic pipes and drips from each nozzle near the crop. It economises the use of water considerably. The prototype drip irrigation set was supplied by M/s Voltas and Messers B.B. Bhaga of Voltas and T. C. Channappa of the University of Agricultural Sciences, Bangalore, helped in the installation and trial run.

The experiment was laid out on mixed clonal tea planted in 1973. There were three treatments, namely, (i) drip irrigation, (ii) drip irrigation with 100 kg N/ha as urea plus 100 kg K_2O per hectare as muriate of potash applied once along with the irrigation water on 16.2.78, and (iii) no irrigation. The same quantity of the above fertilizers was applied broadcast to the other two treatments on 8.4.78. The treatments were replicated twice thus giving a total of 6 plots. Each plot had an area of 318 m^2. Tensiometers were installed at 22 cm, 45 cm, 68 cm and 90 cm depths in one replication. Irrigation was started on 25th January, 1978 and repeated when the tensiometer reading reached 10 cm mercury.

The monthly record on the quantity of water applied and rainfall is given in Table 3.10.

Table 3.10. *Monthly record of rainfall and quantity of water applied*

Month	Rainfall in mm	Quantity of water applied in cm/ha
October, 1977	181.3	—
November, 1977	19.5	—
December, 1977	18.7	—
January, 1978	4.7	1.57
February, 1978	12.7	17.80
March, 1978	62.4	18.40
April, 1978	43.1	13.35

Plucking was started on the 3rd March. The yield for the three treatments during March and April is given in Table 3.11.

Table 3.11. *Yield under different treatments (made tea kg/ha)*

Treatment	Made tea kg/ha			Per cent increase over control
	March	April	Total	
Drip Irrigation*	216	199	415	45
Drip + Fertilizer**	280	221	501	75
No Irrigation* (Control)	106	179	285	0

* Fertilizer applied broadcast on soil
** Fertilizer applied along with drip irrigation

The March crop has increased substantially under drip irrigation. Application of fertilizer along with drip irrigation increased yield further both in March and April. April crop did not increase to the same extent as the March crop. Irrigation gave 45 per cent increase and irrigation with fertilizer resulted in 75 per cent increase in the crop upto April.

WEED CONTROL

Weed competition in young tea

A field experiment (No. 3/76) is being conducted since April 1976 on an area planted with TV 18 in November 1975 to determine the critical period of weed competition in young tea. Weed control was done in certain periods of the year (vide Table 3.12 for treatments) and the plots were left unweeded in the remaining part of the year. The predominant weeds in this trial were *Borreria hispida*, *Paspalum, sp.*, *Scoparia dulcis*, *Digitaria sanguinalis*, *Cyperus sp.*, and *Ageratum conyzoides*, in that order.

When weeds were controlled from April to June and April to September, weed growth during the remaining part of the year was substantially less. In the absence of weed control during these two periods there was profuse weed growth by July and October respectively. The dry matter of weeds accumulated and nitrogen removed by them between April and September respectively were 13,090 kg/ha and 252 kg/ha in the first year and 8,400 kg/ha and 151 kg/ha in the second year. Weed control during this six-month period resulted in better bush frame and growth (due to more number of primary and secondary branches) and hence higher yield (of made tea) i.e. 193 per cent increase in the first year and 355 per cent in the second year (Table 3.12).

Table 3.12. *Effect of weed competition at different periods of the year on the yield of young tea*

Weed control period	No. of Months	Made tea 1977 kg/ha*	1977 % increase	1978 kg/ha*	1978 % increase
No weeding	—	12.5[e]		211[d]	—
April – June	3	13.8[e]	10	469[b]	122
July – September	3	23.6[b]	89	546[b]	159
October – December	3	12.5[e]	0	269[cd]	27
January – March	3	12.7[e]	1	252[cd]	19
April – September	6	36.6[a]	193	933[a]	355
October – March	6	12.7[e]	1	339[c]	161
April – March	12	34.9[a]	179	925[a]	349

* Yield figures within a column followed by the same letter are not significantly different at the 5% level.

When weeds were controlled between April and September, weed dry matter accumulation and nitrogen removal by them in the following six months (October-March) were only 1,890 kg/ha and 34 kg/ha respectively (Table 3.13). Weed control for all 12 months (April to March) was of no benefit over weed control for six months from April to September.

Table 3.13. *Amount of weed dry matter accumulated in various periods of the year (April 1977 to March 1978) and nitrogen removal*

Weed infestation period	Duration (months)	Dry matter of weeds (kg/ha)	Nitrogen removal (kg/ha)
April – September	6	8,400	151
October – March	6	1,890	34
January – September	9	10,200	186
April – December	9	9,060	163
July – March	9	4,020	72
October – June	9	2,520	45

It is, therefore, suggested that weed control during the critical period of April to September is essential for the management of young tea.

Chemical weed control in nursery

In field trial of last year (Annual Report 1976-77), the new herbicides oxidiazon, basalin, alachlor, and butachlor showed promise. This year, an experiment with split plot design was conducted. As main treatments, herbicides were applied to soil alone (at 2 kg/ha*) or in combination (at 1 kg/ha) with simazine (1 kg/ha) 15 days before planting TV 18 cuttings. The three sub treatments were: (i) no further herbicide application, (ii) alachlor application at 2 kg/ha as emulsifiable concentrate (EC) and (iii) alachlor at 2 kg/ha as granules. Sub treatments were applied $3\frac{1}{2}$ months after the main treatments were begun.

The data indicated good control by oxidiazon, basalin and simazine of mixed weeds dominated by *Borreria hispida* for upto $3\frac{1}{2}$ months. Tank mixing basalin or oxidiazon (1 kg/ha) with simazine (1 kg/ha) gave 85 to 88 per cent weed control for $3\frac{1}{2}$ months. These two new herbicides had no adverse effect on callus formation, rooting of the cuttings, and shoot growth of tea.

Table 3.14. *Effect of granular application of alachlor to soil on weed control in clonal nursery*

Alachlor formulation	Rate (kg/ha)	Weed control (%) days after application 45	105
None		48	10
Emulsi. concen.	2.0	80	62
Granules	2.0	86	66

* Rates of all herbicides discussed in this Report are expressed as kilograms active ingredient per hectare and abbreviated as kg/ha.

Regarding sub treatments, there was no difference in the effect of EC and granular formulations of alachlor on the weeds present; they had 80 to 86 per cent and 62 to 66 per cent weed control 45 days and 105 days after their application (Table 3.14). Further research on the effects of granular formulation of herbicides is in progress.

CONTROL OF INDIVIDUAL WEEDS

1. **Imperata cylindrica and Paspalum conjugatum :** The experiment (No. 4/76) initiated in May 1976 in an unshaded six-year old tea severealy infested

with *Imperata* (70%) and *Paspalum* (20%), has been continued in 1977 also. As in 1976, the mechanical treatments (*cheeling* and forkhoeing) and herbicide treatments were applied three times in the year.

Table 3.15. *Effect of various herbicides on the control of field infestation of Imperata cylindrica and Paspalum conjugatum and yield of tea*

Treatment	Herbicide Rate per applic. (kg/ha)	Weed control (%) *Imperata*	Weed control (%) *Paspalum*	Yield Made tea (kg/ha)	% increaase
No weed control	-	0	0	875	-
Cheeling (3)		35	70	1076	23
Fork hoeing (3)		48	80	1118	28
Dalapon (2); 2,4-D (1)	3.0 0.8	60	45	1152	32
Paraquat (2); 2,4-D (1)	0.3 0.8	32	23	1099	26
Dalapon (1); Paraquat (1); 2,4-D (1)	3.0 0.3 0.8	65	10	1188	36
Glyphosate (3)	0.4	95	85	1573	80
Glyphosate (1); 2,4-D (2)	0.4 0.8	90	75	1543	77

Number in parenthesis indicates the number of applications of the treatment in the year.

Glyphosate was significantly superior to all other treatments in controlling *Imperata* and *Paspalum* (Table 3.15). The effect of dalapon applied twice was at par with dalapon once initially followed by paraquat. Repeat application of paraquat was only partially effective. On *Imperata*, forkhoeing (48%) was superior to *cheeling* (33%), while on *Paspalum* both treatments showed similar effect.

2. **Borreria hispida :** In one trial, glyphosate and 2,4-D (sodium salt), were applied alone and in combination, on a very severely infested near-mature growth of Borreria. Glyphosate had little effect at 0.2 and 0.4 kg/ha. 2,4-D showed very good effect at 0.8 kg/ha while it had a moderate effect at 0.4 kg/ha. In a tank mix, 0.2 and 0.4 kg/ha of glyphosate, however, markedly enhanced the effect of the lower rate (0.4 kg/ha) of 2,4-D indicating a possible synergistic interaction between these herbicides. This synergism was also evident at the higher rate of 2,4-D, but only for 2 weeks. There was, however, no difference in the final weed control efficacy between 0.8 kg/ha 2,4-D applied alone or in tank mix with glyphosate.

In another trial 2,4-D (sodium salt at 0.8 kg/ha and dimethylamine salt at 0.5 kg/ha) and paraquat (0.2 and 0.3 kg/ha) were applied alone and in combination at postemergence on a near-mature severe *Borreria* infestation. The data (Table 3.16) indicated that paraquat (Gramoxone) alone was only partially effective. 2,4-D, applied as sodium salt (Fernoxone) or dimethylamine salt (Weedar 96) was very effective. Tank mixing of paraquat neither improved nor reduced the effect of 2,4-D. When paraquat was applied, it scorched only a small portion of the foliage, leaving a substantial leaf area for normal absorption of 2,4-D. Being a translocated herbicide, 2,4-D is readily absorbed and translocated within the plant.

Table 3.16. *Effect of 2,4-D applied alone and in combination with paraquat on the control of Borreria hispida*

Herbicide	Rate (kg/ha)	Weed control (%) Weeks after spraying 1	2	3	5
None	—	0	0	0	0
2, 4-D sodium salt	0.8	32	47	90	100
2, 4-D amine salt (Weedar 96)	0.5	33	55	100	100
Paraquat	0.3	22	40	18	43
2,4-D sodium salt	0.8	36	72	92	100
+ Paraquat	+ 0.3				
2,4-D amine salt	0.5				
+ Paraquat	+ 0.3	35	55	88	100

These results suggest that when only broadleaf weeds are to be controlled, 2,4-D alone will be adequate. But when 2,4-D paraquat mixture is applied on a mixed weed population, 2,4-D kills *Borreria*, and other paraquat-tolerant broadleaf weeds, and paraquat controls grasses and a few broadleaf weeds.

3. **Setaria palmifolia:** As in 1976, the pot trials conducted this year also showed that glyphosate was the most effective of all the herbicides tested and that glyphosate and 2,4-D interacted synergistically resulting in the enhancement of glyphosate activity.

Last year, the effect of paraquat was found enhanced when 2,4-D (0.8 kg/ha) was tank mixed (Annual Report 1976-77). This year's data confirmed this finding particularly at 0.2 kg/ha of paraquat. 2,4-D had no effect. Similarly, addition of Triton AE (a surfactant) at 0.06% improved the activity of paraquat particularly at the low rate of 0.2 kg/ha. It is possible that 2,4-D and Triton AE are enhancing the penetration of paraquat into the foliage of *Setaria*, resulting in greater effect. This work is being pursued further.

The effect of tank mixing of glyphosate and paraquat was also studied on *Setaria*. When the mixture was applied, the toxicity symptoms, (rapid desiccation, scorching of the foliage, quick regrowth, etc.) were typical of paraquat applied alone (Table 3.17). When glyphosate (0.4 kg/ha) was applied alone it had eradi-

Table 3.17. *Effect of paraquat and glyphosate applied alone and in combination on Setaria palmifolia*

Herbicide	Rate (kg/ha)	Weed control (%) Weeks after application 1	2	6
None	—	0	0	0
Paraquat	0.2	47	27	12
Paraquat	0.3	50	27	10
Glyphosate	0.4	88	90	95
Glyphosate + paraquat	0.2	63	33	18
Glyphosate + paraquat	0.4 0.3	60	36	20

cated the weed completely. These results suggest that the rapid contact action of paraquat prevents the normal absorption of glyphosate by the foliage.

When MSMA and RH 315 were applied alone they showed moderate effect on *Setaria*. However, tank mixing of either of them (at 1 kg/ha of MSMA and 0.75 of RH-315) with paraquat (0.15 kg/ha), resulted in greater residual activity of the later. Further research in this area is underway.

Effect of herbicide regimes on the yield of tea

Three field trials were conducted to study the effect of various herbicide regimes on weed control and yield of tea.

1. In the experiment (No. 4/76) on the control of *Imperata* and *Paspalum* in six-year old mature tea discussed earlier, green leaf was plucked for 13 weeks between September and November 1976, and during the entire plucking season (March-November) in 1977.

Glyphosate which controlled *Imperata* and *Paspalum* very effectively, increased the yield by 50 per cent in 1976 and about 80 per cent in 1977 (Table 3.15). Dalapon, paraquat, and dalapon followed by paraquat (sequential) treatments also increased the yield by 17 to 28 per cent in 1976 and 26 to 36 per cent in 1977. *Cheeling* was as effective as forkhoeing.

2. In another trial (No. 1/77) in seven-year old tea infested mostly by perennial grasses, glyphosate was applied in end April as postemergence at 0.4, 0.8, and 1.6 kg/ha. Since control of perennial grasses, particularly *Imperata*, results in *Borreria* infestation, glyphosate (0.4 kg/ha) application was followed, after one month, by soil-active herbicides such as simazine, diuron, and atrazine, at 2 kg/ha. In another treatment, glyphosate (0.4 kg/ha) was repeated once after one month.

Application of glyphosate initially and followed (after one month) by simazine, diuron, or atrazine gave excellent control of *Borreria* and also resulted in much better control of *Paspalum*. Diuron-paraquat-Teepol mixture was moderately effective, while MSMA showed better control of only *Paspalum*. Data on yield of tea showed no significant difference among the treatments. However, all weed control treatments increased the yield by 114 to 124 per cent.

3. In yet another experiment (No. 2/77) 2 kg/ha each of simazine, diuron, alachlor, and butachlor and 1 kg + 1 kg/ha of simazine + alachlor simazine + butachlor, diuron + alachlor, and diuron + butachlor were applied in April at preemergence after *cheeling* in a seven-year old clonal tea. In treatments where herbicides were applied alone, followup weed control was done by *cheeling* in end June.

All treatments had only a moderate control of *Imperata* (40 to 50 per cent), and this effect lasted for only three months. Although there were no significant differences in yield among the treatments even this moderate degree of weed control resulted in an yield increase of 12 to 21 per cent. Cheeling three times in the year increased the yield by 11 per cent.

Allelopathic effect of Imperata cylindrica

Two pot trials were conducted to study the effect of *Imperata* on the germination and emergence of other weed species. Rhizomes of *Imperata* were placed on top of the soil or 8 cm below soil surface. In another treatment, extract of 100 g rhizomes was applied in the beginning and again after one month. These three treatments were compared with a control where no rhizome material or extract was used.

Placement of rhizomes either on top of the soil or below soil surface inhibited the emergence of *Borreria hispida* after six weeks (Table 3.18). This effect of *Imperata* which is allelopathic in nature, was not evident

Table 3.18. *Effect of Imperata cylindrica on the germination of other weed species*

Placement of *Imperata* rhizomes in soil	Stand counts of weed species					
	2 Weeks		6 Weeks		15 Weeks	
	B*	D*	B	D	B	D
8 cm deep	46	6	18	4	7	6
Soil surface	48	6	21	5	8	11
None but rhizome extract applied (twice) to soil	48	7	40	4	42	12
None (control)	44	5	38	6	43	8

*"B" stands for *Borreria hispida* and "D" for *Digitaria sanguinalis*.

when rhizome extract was used. Allelopathy is caused by exudation of certain chemical substances or toxins which inhibit the germination and/or growth of other weed species. These toxins are exuded by the rhizomes or roots or both. The fact that inhibitory effects were seen long after planting rhizomes (six weeks) did indicate that roots arising from the rhizomes are apparently the source of these toxins.

Weed seed population and periodicity of weed seed germination.

In order to study the periodicity of weed germination, a pot trial was undertaken by using the soil of four locations in Borbhetta. The top soil was either disturbed (stirred) every month or left undisturbed during the entire period of study (May to October).

Weed population differed with the location of the soil. In all soils, *Borreria* was the major weed followed by *Cyperus pilosus* and *Digitaria sanguinalis* (Table 3.19). Weed population under undistrubed soil conditions remained static all through the experimental period. Stirring of top soil every month always resulted in fresh germination of *Borreria* and *Cyperus*. These results suggest that mechanical stirring of the soil is very conducive

to fresh weed germination and weed growth, and hence soil disturbance should be avoided as far as practicable.

Table 3.19. *Weed seed germination as affected by disturbance of soil surface**

Weed species	No. of seedlings/pot						
	Undisturbed soil (Maximum No. of seedlings emerged)	Disturbed soil					
		Weeks after beginning					
		3	8	11	15	20	Total
Borreria Hispida	76	80	54	35	26	20	215
Cyperus sp.	3	3	6	6	4	3	22
Digitaria sanguinalis	10	4	2	2	1	1	10

*The data represent the mean values of soils from four locations.

Slow-release formulation of 2,4-D and dalapon

Field studies were conducted to determine the efficacy of slow-release formulation and the normal wettable powder fomulation of 2,4-D and dalapon (of National Chemical Laboratory, Poona) on *Borreria* and *Imperata* respectively. They were applied on soil at 8 and 12 kg/ha (total product) after *cheeling* the ground.

The performance of the slow-release formulation of 2,4-D and dalapon was not very encouraging. Further tests will be conducted at much higher rates.

Check Testing

The 2,4-D sodium salt fomulation of Parimal Organic Chemicals Limited, Bombay was check trested during the year and it received certification of approval for use in tea.

Three new polyamine formulations of 2,4-D of India Carbon Ltd. have been check tested at 0.4 and 0.8 kg/ha. Their effects on *Borreria* were comparable with those of the standard sodium salt and dimethylamine salt of 2,4-D. These tests will be continued next year also.

Quality testing of herbicides

Fourteen samples of 2,4-D, dalapon, paraquat and diuron trade formulations received from 10 estates were tested for quality. One out of two Gramoxone samples and one out of eight 2,4-D sodium salt samples were substandard. All the others were normal.

Efficiency of use of urea nitrogen was found to be about 30 per cent at all levels and methods of application. Selective measurement of aluminium and iron phosphates should be a reliable index for assessment of potentially available phosphate in acid tea soils. Higher levels of potash manuring economises water use by reducing evapotranspirational losses. Application of phosphate depressed zinc uptake by young tea grown in sand culture medium with nutrient solution.

Absorption of zinc by young tea from foliar and soil applied zinc sulphate was completed within 24 hours and three weeks respectively. As far as uptake is concerned foliar zinc was at least ten times more effective than soil applied zinc. More zinc was absorped by different plant fractions from the chelated source as compared to the non-chelated one.

An uniform method of sampling for different nutrients in leaf analysis may not be possible in view of variations due to genetical differences, leaf position, plant organs and hours of sampling.

By laying out sub-soil pipe drains at a depth of 150 cm instead of the conventional open drains of 75 cm depth, ground water table could be successfully controlled. During peak monsoon periods, ground water table under system of deeper sub-soil drains was lower by a meter as compared to shallow open drains; its utility on crop yield is now under investigation. In area with restricted outfall, pump drainage system was found to be useful and economic. Tentative design criteria of sub-soil pipe drainage system for Dooars and Assam have been computed for trying out at estate level.

STUDIES ON NITROGEN NUTRITION

Leaching loss and recovery of urea nitrogen

This experiment, which was started in April, 1976, has been completed now. The object of the experiment was to compare the effects of single and split application of urea on leaching loss of applied nitrogen, total nitrogen uptake by plants and changes in soil nitrogen status. Similar investigations with ammonium sulphate were reported earlier (c.f. Annual Scientific Report, 1974-75, P. 24).

The experiment was carried out in pots under glasshouse conditions using sandy loam soil and eighteen months old TV1 plants. A basal dressing of phosphate, potash, zinc and magnesium was given at the rates of 40 kg P_2O_5, 80 kg K_2O, 20 kg $ZnSO_4$ and 20 kg $MgSO_4$ per hectare respectively.

Nitrogen treatments were :

T_1 — No nitrogen.

T_2 — 100 kg N/ha in 5 split applications (364 mg N/plant).

T_3 — 100 kg N/ha in one application (364 mg N/plant).

T_4 — 200 kg N/ha in five applications (728 mg N/plant).

T_5 — 200 kg N/ha in one application (-do-) .

There were twenty replications of each treatment in a randomised block design, out of which four replicates were harvested every five months to estimate the total nitrogen uptake by the plants. Plants were subjected to 15 cm rainfall every month and leachates were collected for estimating monthly loss of applied nitrogen in the form of nitrate and ammonia. Changes in soil nitrogen status, as a result of the given treatments were also followed at five monthly intervals. Results of analysis at the end of twentyfive months are given in Table 4·01.

Table 4.01. *Effect of nitrogen treatments on nitrogen uptake, leaching loss of applied nitrogen and soil nitrogen status after twentyfive months*

Treatment (mg N/plant pot)	N uptake (mg/plant pot)	Leaching loss (mg N/plant-pot)	Soil N (mg/plant-pot)
Control	429.4	226.2	7068.0
364 mg in 5 splits	514.6	369.7	7136.0
364 mg in one application	536.5	407.5	7204.0
728 mg in 5 splits	647.2	486.3	7252.0
728 mg in one application	635.7	530.5	7344.0
Level of significance at P<	0.001	0.001	Not significant
C.V. %	6.2	5.5	6.2
C.D. at 5%	21.83	14.09	—

From table 4·01 it is seen that total nitrogen uptake by plants and leaching loss of applied nitrogen increased progressively with increasing levels of nitrogen application in the form of urea. Total nitrogen content of the soil, however, remained unaffected by nitrogen application. This was true for both single and split methods of application of urea nitrogen.

Variations in total nitrogen uptake by plant, cumulative leaching loss of applied nitrogen and nitrogen content of soils at different periods of harvesting are given in Table 4.02.

Table 4·02. *Variations of nitrogen uptake, cumulative loss of nitrogen and soil nitrogen at different periods of harvest*

Factors	Periods of harvesting in months					C.D. at 5%	Level of significance at P<
	Sept.'76 5 months	Feb.'77 10 months	July. '77 15 months	Dec. '77 20 months	May. '78 25 months		
Total nitrogen uptake (mg/plant)	595.1	542.4	530.7	556.3	538.9	21.83	0.001
Cumulative leaching loss of N (mg/plant pot)	174.3	338.5	445.8	500.8	553.7	14.09	0.001
Soil N (mg/plant pot)	7116.0	7244.0	7176.0	7196.0	7272.0	—	Not signifincat

From Table 4·02 it is seen that total nitrogen uptake by plants was highest during the first harvest after five months. During subsequent harvests nitrogen uptake differed very little with the exception of December '77 sampling which was slightly higher than at other periods. Cumulative leaching losses of nitrogen,when expressed as percentage of the total loss (i.e. May '78 data), were found to be about 31, 61, 80 and 90 per cents for 1st, 2nd, 3rd and 4th five monthly periods respectively. There was no significant change in the soil nitrogen status throughout the period of the experiment.

Effects of single and split methods of nitrogen application on the total nitrogen uptake, leaching loss of applied nitrogen and soil nitrogen content is shown in Table 4·03.

Table 4·03. *Effect of single and split application of nitrogen on nitrogen uptake, loss of nitrogen and soil nitrogen content*

Factors	Method of N application		C.D. at 5%	Level of significance at P
	Split	Single		
Total nitrogen uptake mg/plant	589.9	586.1		Not significant.
Leaching loss of nitrogen (mg/plant pot	428.0	469.0	9.96	0.001
Soil nitrogen (mg/plant pot	7194.0	7274.0	—	Not significant.

From table 4.03 it is seen that total nitrogen uptake by the plants as well as soil nitrogen content did not vary between the two methods of application of nitrogen. Leaching loss of applied nitrogen was, however, found to be lower by 7.5% with split application as compared to single application.

Further, percentage loss of urea nitrogen at different levels of application under both methods, i.e. split and single is shown in Table 4.04.

Table 4·04. *Leaching loss and recovery of urea nitrogen at different levels and methods of nitrogen application*

Treatment		Leaching loss of applied N		Recovery of applied N	
KgN/ha	mg N/ plant pot	Net loss (mg N/ plant pot	Percent Urea N lost	Net recovery (mg N/plant pot)	Per cent urea N recovered
0	0	226.2	—	429.4	—
100	364 mg in 5 splits	369.7	40.0	542.4	31.0
100	364 mg in one appln.	407.5	50.0	536.5	30.0
200	728 mg in 5 splits	486.3	36.0	647.2	30.0
200	728 mg in one appln.	530.5	42.0	635.7	29.0

Leaching loss of urea nitrogen in split application was ten and six per cent less at 100 and 200 kg N/ha levels application respectively as compared to single application. However, no interaction between dose and method of application was observed. Interestingly, loss by leaching did not affect N uptake by plants. Recovery of applied nitrogen by the plants did not show any significant difference between split and single application. The efficiency of use of urea nitrogen was found to be about 30 per cent at all levels and methods of application.

Nitrate reductase activity

Nitrate reductase (N.R.) activity of few clones was measured to find out whether N.R. activity varies between clones or their various components. N.R. activity measures capacity for reduction of nitrate into ammino acid and proteins and thus may explain the possible variable clonal response to added nitrogen.

In this preliminary study, 18 month old plants of the four clones TV1, TV7, TV12 and TV18 were used. TV7 is a China clone, TV12 an Assam, TV18 a Cambod and TV1 is a multiple hybrid. Standard method adopted was to treat the cut-leaf tissue with ice-cooled infiltration medium (potassium nitrate and phosphate buffer, pH 7.5) and incubate at 33°C in the dark on a shaking machine for one hour. Nitrite formed due to reduction of nitrate was estimated by absorptiometry at 540 mμ. Results are given in Table 4.05.

Table 4·05 *Nitrate reductase activity of different clones and their various leaf/plant fractions (mean of three observations)*

Leaf/plant fractions	Clones				Mean
	TV1	TV7	TV12	TV18	
First leaf	600	550	1,050	1,100	825
Second leaf	700	600	1,050	1,050	850
Third leaf	850	100	950	950	712
Internode	1,050	650	1,150	1,300	1,038
Feeder roots	1,100	700	1,250	950	1,000

Mean data of all fractions show that clone TV7 had the lowest N.R. activity and clone TV12 and TV18 had the highest N.R. activity. Clone TV1 occupying an intermediate position. Further intensive work is required to confirm the usefulness of N.R. activity as a factor for explaining variable responses of clones to nitrogen manuring. The internodes and feeder roots generally had higher N.R. activity than the leaves. There was virtually no difference between first and second leaves, while third leaf was slightly lower in N. R. activity with the exception of TV1.

Studies on phosphate nutrition

Exhaustive cropping trial with *Pennisetum pedicellatum* has been completed. During the period of experiment grass was harvested twenty times at monthly intervals. At the end of the experiment none of the pots showed visible signs of phosphate deficiency, although dry matter yield progressively declined. After the thirteenth harvest, very little increase in dry matter yield took place. Relationship between cumulative phosphate

uptake and period of cropping for different levels of phosphate application is shown in Fig. 4·01.

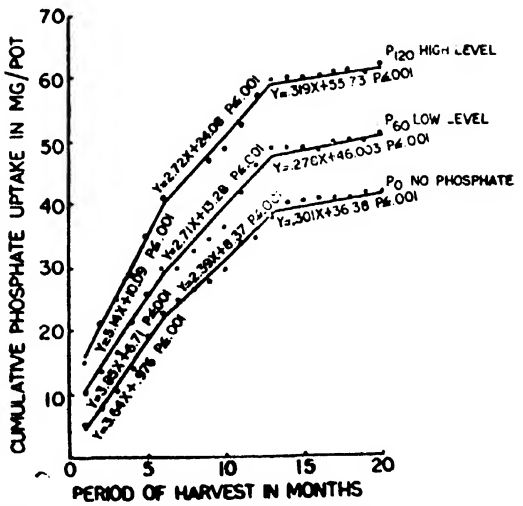


Fig 4·01. Relationship between cumulative phosphate uptake and period of cropping of test crop for different levels of phosphate application

From Fig. 4·01 it is seen that the rates of phosphate uptake are distinctly different for three periods namely, 1st to 6th harvest, 6th to 13th harvest and 13th to 20th harvest. Relationships between cumulative phosphate uptake and period of cropping in these three distinct phases of growth have been worked out from regressions and the uptake rates are given in Table 4·06.

Table 4·06. *Rate of phosphate uptake at differ nt periods of harvest of test crop*

Treatment P_2O_5 kg/ha	Change in rate of phosphate uptake in monthly harvest		
	1st to 6th (mg/month)	7th to 13th (mg/month)	14th to 20th (mg/month)
0	3.644	2.396	0.301
60	3.850(0.206)*	2.708(0.312)*	0.278(0.—0.023)*
120	5.138(1.288)*	2.719(0.323)*	0.319(0.018)*

* difference in rate of uptake between levels of P_2O_5 application

Data show that phosphate uptake increased almost at the same rate at all levels of phosphate application in all the three distinct phases of cropping, with the exception that during the first six months, P uptake was higher at 120 kg P_2O_5/ha application rate. Regression equations for the three phases of growth at different phosphate levels are highly significant ($P < 0.001$). Similar relationships between phosphate uptake by test crop and periods of harvest have also been observed in the case of soils from long-term phosphate manurial experiments used for exhaustive cropping experiment without addition of fresh phosphate.

Relationships between cumulative phosphate uptake by the test crop and rates of application of phosphate in soils of different regions are shown in Fig.4.02(a).

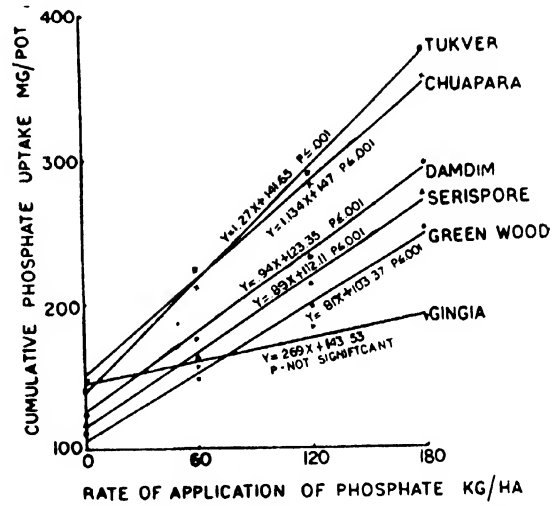


Fig 4.02 (a). Relationship between cumulative phosphate uptake by tea crop and rates of application of phosphate in soils of different regions

Equations relating to these relationships and their level of significance are given in Table 4.07(a).

Table 4. 07(a). *Regression equations between cumulative phosphate uptake and levels of phosphate application*

Soil of T.E.	Region	Soil type	Regression equation	Level of significance at P <
Tukvar	Darjeeling	Sandy loam	Y = 1.27 X + 141.65	0.001
Damdim	Western Dooars	Loamy sand	Y = 0.94 X + 123.35	"
Chuapara	Eastern Dooars	Silty loam	Y = 1.13 X + 147.20	"
Greenwood	South Bank	Silty loam	Y = 0.81 X + 103.37	"
Gingia	North Bank	Loamy sand	Y = 0.27 X + 143.58	N. S.
Serispore	Cachar	Silty clay loam	Y = 0.89 X + 112.11	0.001

Y = Cumulative phosphate uptake in mg/pot, X = Level of phosphate application P_2O_5 kg/ha

From Fig. 4.02(a) it is seen that cumulative phosphate uptake by the test crop from all the regional soils was linearly related to increasing levels of phosphate manuring in a highly significant way. The linear relation observed at Gingia was not significant. It is also seen from the regression coefficients that the rate of change of cumulative phosphate uptake per unit change in phosphate level did not vary much (0.81 to 1.27) between the different regions with the exception of the soil from Gingia T.E.

Further, it was observed, at the end of the experiment, that total phosphate uptake by the test crop differed

between the gardens located in different regions as is evident from figure 4.02(a). It was also confirmed (c.f. Ann. Sci. Rept. 1975-76, p. 22-23 and 1976-77, p.21) that any of the two measurements of soil available phosphate namely water soluble or exchangeable phosphate, can be advantageously employed for prediction of phosphate uptake by the test crop.

The average rate of change of P uptake in recently manured soils worked out to be 1.0 mg per kg of applied phosphate as P_2O_5. However, the rate of change of P_2O_5 uptake from soils under long-term manuring experiments used for exhaustive cropping with the test crop averaged at 2.0 mg per kg of applied P_2O_5, indicating that residual phosphate from long-term manuring was utilised at double the rate as compared to freshly added phosphate fertiliser. (c.f. Table 4.07(b).)

Relationships between cumulative phosphate uptake and rates of application of phosphate over long periods in soils from Borpbhetta field trials are shown in Fig. 4.2(b).

Table 4.07(b). *Regression of cumulative phosphate uptake on levels of phosphate application in long-term field experiments at Borbhetta*

Borbhetta field trials	Soil type	Expt. started in	Past manuring history	Regression equation	Significance level at P<
B-43	Sandy loam	1930	2-1-1 N-P-K- mixture, P_2O_5 at different levels	Y = 2.309 x + 187.764	0.001
B-105	Sandy loam	1960	80 kg N/ha along with P_2O_5 at different levels	Y = 1.963 x + 219.112	0.001

Y = Cumulative phosphate uptake in mg/pot, X = level of phosphate application P_2O_5 kg/ha

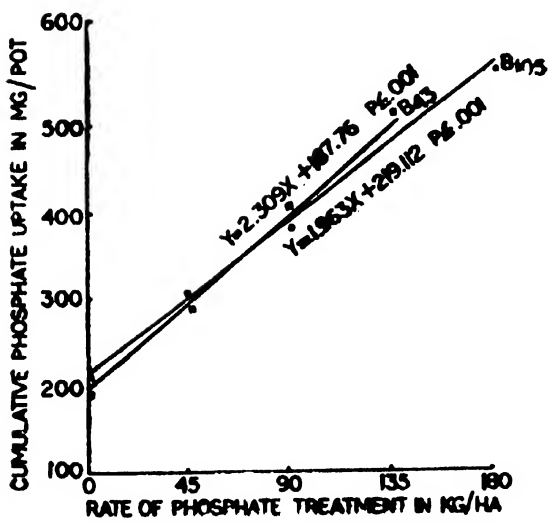


Fig 4·02(b). Relationship between cumulative phosphate uptake and rates of application of phosphate over long periods in soils of Borbhetta field trials B. 43 and B. 105

Effect of exhaustive cropping on different forms of soil phosphate

Soils from the exhaustive cropping trial, which had not received phosphate fertiliser in the past (control pots), were analysed for different fractions of phosphate at the begining and end of the experiment. The purpose was to evaluate the changes, if any, in different native fractions of phosphate, as well as to find out which fraction was affected most. In general, significant decreases were observed in individual inorganic fractions due to continuous cropping with grass, as shown in Table 4.08.

The utilisation of aluminium phosphate fraction by the test crop was on average about four times more than that of either iron or calcium phosphate fractions under exhaustive cropping. The utilisation of aluminium phosphate by the test crop from different soils decreased in the order South Bank, Dooars, North Bank, Cachar and Darjeeling. It is of interest to note that from Darjeeling, North Bank and Cachar soils, both aluminium and iron phosphate were used up almost in the same

Table 4.08. *Percentage decreases of inorganic forms of native phosphate due to continuous cropping over a period of twentyone months*

Regions \ P forms	Aluminium phosphate	Iron phosphate	Calcium phosphate	Total
Darjeeling	17	14	8	39
Eastern Dooars	31	4	5	40
Western Dooars	34	3	3	40
South Bank	56	3	7	66
North Bank	19	13	5	37
Cachar	19	10	6	35
Average	29	8	6	43

proportion, whereas in Dooars and South Bank the utilisation of iron phosphate was rather insignificant as compared to the aluminium phosphate fraction. Decrease in the level of calcium phosphate was low and did not vary widely in the soils from the different regions. For an index of availability of soils phosphate in different regional soils, both aluminium and iron phosphates should, therefore, be considered together.

STUDIES ON POTASH NUTRITION

Influence of potash on water use by young tea

Layout of this experiment, objectives and some of the results were reported last year (c.f. Ann. Sci. Rept., 1976-77, p. 23-24).

(a) Effect of potash application on leaf potash concentration at different moisture regimes

Leaf potash concentration increased proportionately with the increasing levels of potash application (Table 4.09) and the relationship was highly significant

($P < 0.01$). The effect of soil moisture content on leaf potash was also highly significant ($P < 0.01$), irrespective of the levels of potash application. The moisture × potash interaction was also significant ($P < 0.05$). At higher moisture stress (half field capacity), effect of potash application on the concentration of leaf potash was more pronounced than at other moisture regims, *e.g.*, at M_2K_1 percentage K_2O in leaf was 1.96 as against 1.37 at M_0K_4.

Table 4.09. *Effect of potash and soil moisture regime on potash concentration in leaf*

Kg of K_2O/ha	Leaf potash concentration (p.c. on dry wt. basis) under different moisture regimes.			
	Mo	M1	M2	Mean
0	1.37	1.41	1.51	1.44
50	1.41	1.49	1.60	1.50
100	1.46	1.51	1.69	1.56
150	1.54	1.65	1.83	1.67
200	1.73	1.80	1.96	1.84
Mean	1.51	1.58	1.73	—

C. D. at P 0.05, for M 0.06
K 0.26
MxK 0.45

Mo 18% gravimetric moisture in soil (field capacity)
M1 14% gravimetric moisture in soil (¾th field capacity).
M2 9% gravimetric moisture in soil (½field capacity).

(b) Evapotranspirational loss as influenced by potash at different moisture levels

The main effect of potash on the evapo transpirational losses (E.T. loss) was found to be highly significant ($P < 0.01$). As the levels of potash application increased the E.T. loss gradually decreased (Table 4.10). There was, however, no significant difference in the effect of potash on the E.T. loss between the levels 50 and 100 kg K_2O per hectare application rates. Evapo-transpirational losses, as expected, decreased progressively in a significant way ($P < 0.01$) with gradual decrease in soil moisture content. The interaction between the effects of potash and moisture was not, however, statistically significant.

Table 4.10. *Effect of potash and soil moisture regime on evapotranspirational loss during the experiment.*

Kg of K_2O/ha	E. T. loss, gm/pot under different moisture regimes			Mean
	MO	M1	M2	
0	8309	7077	6183	7223
50	7922	6812	5558	6764
100	7657	6625	5325	6536
150	7059	5999	4937	5998
200	6358	5328	3497	5394

C. D. at P = 0.05, For M = 360
K = 378

(c) Water use efficiency as influenced by potash at different moisture levels

Water use efficiency is the ratio of dry matter yield (total d.m.) to amount of water used by the plant during the period of its growth (total E.T. loss).

Results in Table 4.11 show that water use efficiency increased progressively in a significant way with increasing levels of potash application ($P < 0.001$). This is true at all the three moisture regimes. The interaction between moisture and potash on water use efficiency was also highly significant ($P < 0.01$). The water use efficiency under treatment M_2K_4 (½field capacity and 200 kg K_2O/ha) was found to be almost three times higher than under treatment M_0K_0 (field capacity and no potash).

Table 4.11. *Effect of potash and soil moisture content on water use efficiency*

Kg of K_2O	Water use efficiency, gm/ml × 10^4			Mean
	MO	M1	M2	
0	19	23	29	24
50	23	27	36	29
100	23	29	41	31
150	27	35	46	36
200	33	44	55	44
Mean	23	32	42	—

C. D. at P = 0.05, For M = 3
K = 7
For M × K = 1

(d) Water use economy

Figure 4.03 shows the relationship between dry matter yield and E.T. loss at various levels of potash application namely, 0, 100 and 200 kg K_2O/ha.

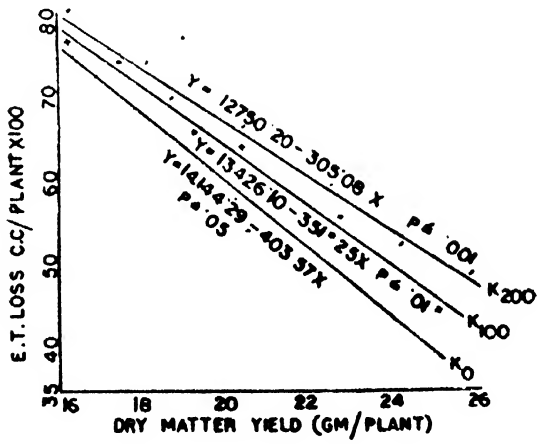


Fig 4.03. Relationship between dry matter yield and E.T. loss at various levels of potash application

From the figure it is seen that, irrespective of the levels of potash application, a linear negative relation exists between dry matter yield and E.T. loss.

The regression equations and their level of significance are shown below :

Potash level	Regression Equation	Diff. in 'b' value	r
Control	Y=14144.29-403.57X	—	-0.5219*
100 kg K_2O/ ha	Y=13426.10-351.25X	52.3	-0.7129**
200 „ „	Y=12750.20-305.08X	98.5	-0.7137**

From the 'b' values of the above equations (underlined) i.e., the rate of change of E.T. loss per unit dry matter yield, it is seen that as the rate of application of potash is increased from 0-200 kg K_2O/ha, the rate of E.T. loss per unit dry matter yield decreased. Compared to no potash treatment, 100 and 200 kg K_2O/ha application rates resulted respectively in 52.3 and 98.5 ml less water consumption per unit dry matter formation.

Capacity-intensity relationship of soil potassium

Studies on potassium adsorption isotherm (as reported last year) have been continued further, where a large number of soils from different tea growing regions of North East India were used. The adsorption isotherms of all the soils so far examined were almost idential. The general nature of potassium adsorption isotherm of North East India tea soils is shown in Fig. 4.04.

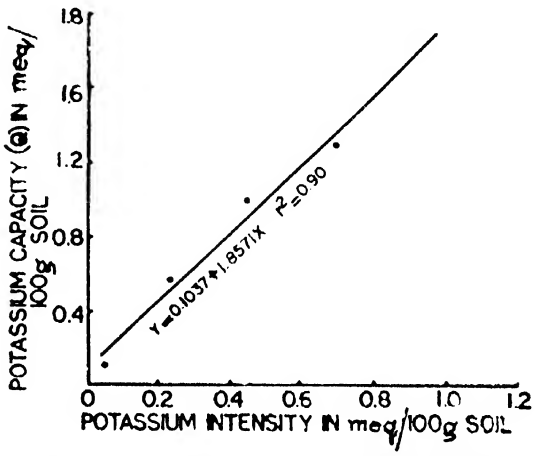


Fig 4.04. Potassium absorpion isotherm of North East India tea soils

From Fig. 4.04, it is seen that instantaneously available (I) and potentially available (Q) potassium are linearly correlated in a highly significant way ($P < 0.001$). From the nature of the adsorption isotherm it can be concluded that tea soils generally have low fixation capacity for added potassium. Further, in these soils release of added potassium is fast, since immediately available potassium changes in direct proportion to potentially available potassium. It can, therefore, be inferred that the observed variable K response in different tea growing regions of North East India is not due to any difference in K fixation/release capacity of the soils, but is linked with variable exchangeable K status (capacity) of these soils.

Further, there was little variation in the potential buffer capacity (P.B.C.) i.e., slope of the adsorption isotherm, of these soils as can be seen from Table 4.12.

These results confirm that potassium release/fixation capacity of different tea soils of N.E. India is of the same pattern. Hence any difference in potash response between different soils may be attributed to differences in exchangeable (potentially available) potassium content rather than differences in K exchange capacity.

Table 4.12. *Mean potential buffer capacity (P.B.C.) of regional soils, in m eq/ 100 g soils*

Region	P. B. C. of soil
North Bank	2.24
South Bank	2.22
Cachar	1.89
Dooars	1.90
Darjeeling	2.29
Mean	2.16

STUDIES ON ZINC NUTRITION

Correlation studies between available zinc and other soil factors

Large number of soil samples from different regions of North East India have been analysed for pH, organic matter, finer fractions like silt and clay, available phosphate and available zinc contents with an aim to find out the influence of above mentioned factors on the availability of native zinc. Data are now being processed for multiple correlation analysis in computer. The details of these soils are as follows :

Region	Number of estates	Number of soil samples
1. South Bank of Brahmaputra	35	105*
2. North Bank of Brahmaputra	34	102*
3. Cachar district	20	60*
4. Darjeeling district	20	240**
5. Dooars & Terai	36	108*

*estate $\times$3 depths, **estate $\times$2 aspects $\times$ 3 elevations $\times$ 2 depths.

Studies on the interaction of zinc and phosphate

An experiment was conducted in sand culture medium under glasshouse conditions to find out the possible interaction of zinc and phosphate on the uptake of both nutrients. Clonal (TV1) plants were grown in sand culture for a period of four months and then supplied with Hewitt's nutrient solution at quarter strength minus zinc and phosphate. pH of the medium was kept at 3.5. Zinc was supplied at levels 0.16 (Zn1), 0.033 (Zn2), 0.066 (Zn3) ppm and phosphate was supplied at levels 10.0 (P1), 20.0(P2) and 30.0 (P3) ppm, twice weekly for a period of six months from June to November,1977. There were five replications for each treatment. The above concentrations of Zn and P correspond to $\frac{1}{4}$, $\frac{1}{2}$ and full strengths of Zn and P in Hewitt's solution. Plants were harvested one month after the Zn and P treatments

were completed and analysed for concentration of Zinc in leaf. Results are given in Table 4.13.

Table 4.13. *Influence of varying levels of Zn and P supply in Hewitt's solution on the zinc content (ppm) of leaf*

P \ Zn	Zn_1	Zn_2	Zn_3	Mean
P1	92.88	116.64	122.08	110.53
P2	44.52	49.64	78.16	57.44
P3	24.68	28.76	47.04	33.49
Mean	54.03	65.01	82.43	—

C. D. at 5% for Zn and P = 11.06

From table 4.13 it is seen that concentration of zinc in leaf increased significantly ($P < 0.001$) with increasing levels of zinc application; whereas with increasing supply of phosphate, zinc concentration in leaf decreased significantly ($P < 0.001$). Phosphate x Zinc interaction was, however, found to be non-significant.

ZINC UPTAKE BY YOUNG TEA

(i) Foliar application of zinc sulphate

For this experiment one year old TV1 sleeve grown plants were used. Zinc was applied as zinc sulphate at rates 0, 0.5, 1.0, 1.5 and 2.0 kg zinc sulphate per hectare. After spraying of zinc sulphate, plants were harvested at intervals of 4, 8, 24 and 32 hours. Plants were fractionated into leaf, stem and root and each was analysed seperately for zinc content. Results are shown in Figs. 4.05 and 4.06.

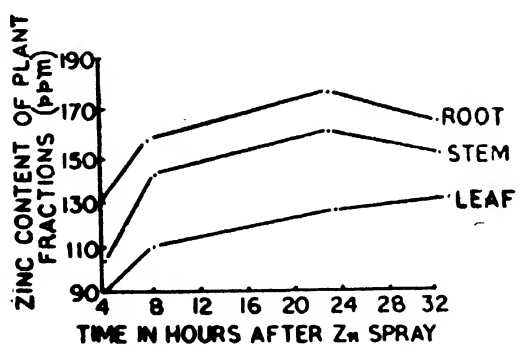


Fig 4.05. Rate of absorption of zinc from foliar applied zinc sulphate

Figure 4.05 shows that under any one level of application, roots contained more zinc than leaf or stem, the order of adsorption being root > stem > leaf. On an average, about 36 per cent more zinc was absorped in roots and 20 per cent more in stems as compared to leaves. Absorption of zinc by various plant parts was almost completed within 24 hrs., of which maximum absorption took place during the first eight hours.

Figure 4.06 shows that zinc concentration of all the plant parts increased with increasing levels of application of zinc sulphate. Absorption of zinc was linear

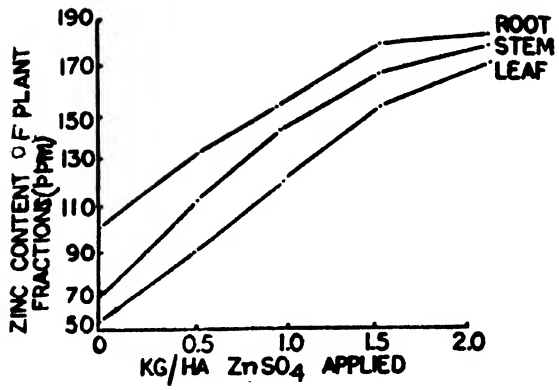


Fig 4.06. Absorption of zinc at varying levels of foliar applied zinc sulphate

upto 1.5 kg $ZnSO_4$ per hectare and, thereafter, the rate of absorption declined.

(ii) Soil application of zinc sulphate

As in foliar experiment reported above one year old sleeve grown TV1 plants were treated with zinc sulphate at five levels, *viz.*, 0, 5, 10, 15 and 20 kg $ZnSO_4$/ha. Zinc sulphate was applied in solution form on soil surface and watered. Plants were harvested at intervals of 7, 14, 21 and 28 days and analysed for Zn content in the same way as that of foliar application. Results are shown in Figs. 4.07 and 4.08.

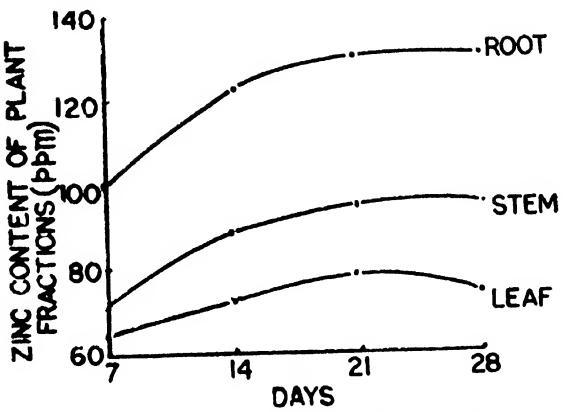


Fig 4.07. Absorption of zinc from soil applied zinc sulphate

Fig. 4.07 shows that when zinc application was done thr ugh soil then also root contained more zinc than leaf or stem, the order of absorption being root > stem > leaf. Absorption from soil applied zinc was completed within a period of three weeks.

Figure 4.08 shows that zinc content of all the plant parts increased with increasing levels of application of zinc sulphate. Leaf and root showed linear increase upto 20 kg $ZnSO_4$ per hectare.

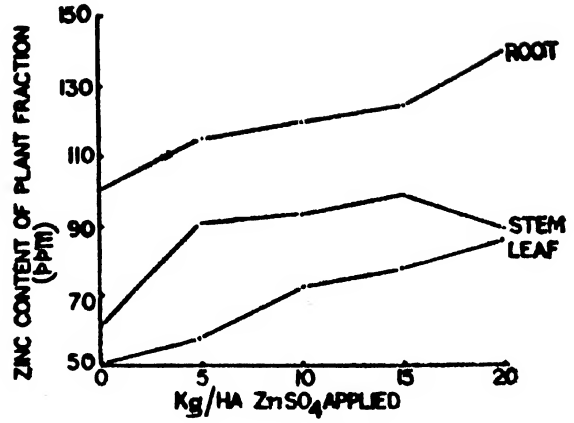


Fig 4.08. Absorption of zinc at varying levels of soil applied zinc sulphate

From a comparison of foliar and soil application of zinc as shown in Fig. 4.09 it is seen that foliar application at a much lower rate (at least one-tenth) was as effective as higher rates of soil application from the point of view of uptake.

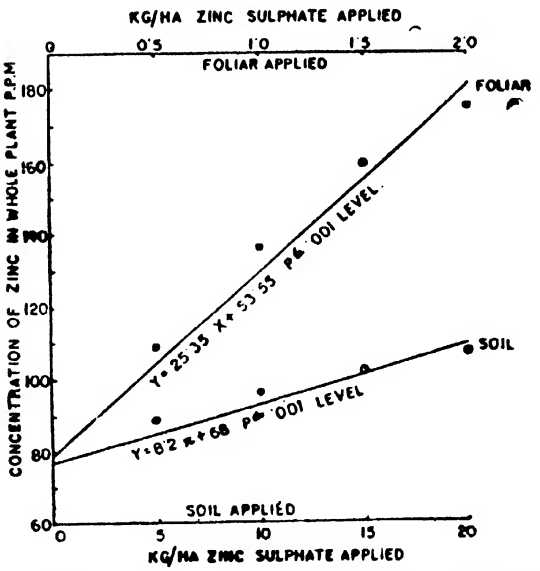


Fig 4.09. Comparison of absorption of Zn by plant from foliar and soil applied zinc sulphate

(iii) Forms of zinc and uptake

As in foliar experiment reported under (i), one year old sleeve grown TV1 plants were treated with chelated and non-chelated forms of zinc. Uptake of zinc by various plant parts at periodic intervals from foliar application of zinc sulphate and zinc chelate is shown in Table 4.14. Both zinc sulphate and zinc chelate were applied at equivalent rate of 1.0 kg Zn/ha, using a spray concentration of 5.0 per cent W/V.

Table 4.14. *Absorption of zinc (ppm) by different plant parts with time from different zinc sources.*

Plant parts	Forms of zinc	Hours after foliar application of zinc			
		4	8	24	32
Leaf	Zinc sulphate	110	152	129	110
	Zinc chelate	145	199	194	196
Stem	Zinc sulphate	132	173	169	130
	Zinc chelate	185	219	206	209
Root	Zinc sulphate	159	176	187	188
	Zinc chelate	204	253	294	247

Results show that from the chelated source zinc was absorped in larger quantities by different plant organs. than from the non-chelated source at successive intervals from spraying. After 8 hours, when absorption completed, about 48, 35 and 40 per cent more zinc was absorped by leaf, stem and root, respectively from the chelated source.

It was also observed that by and large zinc from $ZnSO_4$ source in leaf and stem moved out after 8 hrs. possibly into the root which showed an increase at 24 and 32 hrs. The chelated source of zinc did not show this phenomenon, with the exception of root zinc at 32 hrs.

STUDIES ON SOIL/LEAF MANGANESE

Fractionation of soil manganese

Soil profile samples collected down to a depth of 120 cm were analysed for various forms of available manganese. Results so far obtained show that water soluble fraction varies between 1 to 4 ppm exchangeable fraction varies between 4 to 50 ppm and easily reducible fraction varies between 10 to 100 ppm. The easily reducible form was found to be the highest and water soluble form, the lowest at all depths, exchangeable form occupying an intermediate position. Both exchangeable and easily reducible forms increased generally with increasing depth, the easily reducible form showing a wider variation with depth.

Effect of foliar aplication of manganese on uptake with and without chelating agent

In this experiment manganese was applied in the form of foliar spray as manganese sulphate at rates 0, 5, 10 and 20 ppm Mn (W/V). In another set of treatments, sodium salt of EDTA (ethylene diamine tetra acetic acid), the chelating agent, was applied in 2, 4 and 8 p.c. solution (W/V), alone and in combination with $MnSO_4$. Ten sprays were given at fortnightly intervals before harvesting the young plants. Concentration of manganese in harvested leaves is shown in Table 4.15.

Table 4.15. *Effect of foliar application of $MnSO_4$ and EDTA on leaf manganese concentration*

Treatment	ppm Mn	Treatment	ppm Mn	Treatment	ppm Mn
Control (No Mn)	1027	Control	1027	Control	1027
1% $MnSO_4$	1403	1% $MnSO_4$ + 2% EDTA	875	2% EDTA	1233
2% $MnSO_4$	1683	2% $MnSO_4$ + 4% EDTA	887	4% EDTA	833
4% $MnSO_4$	2650	4% $MnSO_4$ + 8% EDTA	985	8% EDTA	743

It is seen from Table 4.15 that Mn concentration in leaf increased with higher rates of $MnSO_4$ application. EDTA had depressing effect on Mn uptake. However, the depressing effect of EDTA on Mn uptake in this preliminary experiment could be due to the high concentration of applied EDTA, since plants receiving EDTA and EDTA + Mn showed symptoms of scorching and the intensity of scorching increased with increasing concentration of EDTA in spray fluid.

Leaf Analysis

Intensive leaf analysis was carried out during the year, with the object of estimating variations, if any, in N, P, K, Ca, Mg and Zn contents due to (a) genetic differences, (b) position of leaf, (c) other plant organs and (d) time of sampling. This study included five clones, two jats, seven leaf positions, two plant organs and four times of sampling a day. Results are briefly described below :

Analysis of variance showed highly significant difference ($P < 0.001$) due to either clones/jats of tea or due to leaf position/organs in all the nutrient elements except potassium. However, the trends of differences for different nutrients were not the same. Variation due to hours of sampling was found to be highly significant ($P < 0.001$) in the case of Ca, Mg and Zn, but not for N, P, K. As far as potassium is concerned, variations due only to clone/jat of tea were found to be significant ($P < 0.001$). Interaction between clone/jat and leaf position/organs was also found to be highly significant ($P < 0.001$) for all the nutrient elements except potassium. Influence of genetical variations on nutrient contents are shown in Table 4.16(a) and of leaf position and plant organs in Table 4.16(b).

Table 4.16(a). *Variation in average leaf nutrient contents of clones and jats*

Per cent nutrient content	Clones					Jats			
	TV 1	TV 7	TV18	TV 19	TV 20	Lingri	Kharjan	CD at 5%	Level significance
N	2.64	3.05	2.00	1.70	1.74	2.13	2.33	0.13	***
P	0.31	0.26	0.41	0.23	0.19	0.28	0.14	0.03	***
K	2.10	2.12	1.84	1.72	1.75	1.55	1.85	0.34	***
Ca	0.94	0.74	0.49	0.68	0.90	0.44	0.42	0.06	***
Mg	0.19	0.19	0.18	0.28	0.30	0.24	0.24	0.02	***
Zn ppm	45.65	44.86	43.11	62.86	45.08	—	—	2.70	***

In general, TV1 and TV7 compared favourably in their nutrient contents; clones TV19, TV20 and jats Lingri and Kharjan had generally lower nutrient contents, whereas TV18 occupied an intermediate position. Results show that from bud to sixth leaf position, nitrogen and phosphorus contents generally decreased progressively, potassium remained virtually unaltered, calcium content increased steeply and magnesium showed small and irregular changes from leaf to leaf. There was practically no difference in zinc content from second to sixth leaf and these leaves had significantly less zinc than either the bud or first leaf. Petiole contained the maximum quantities of potassium, calcium and magnesium and very low quantities of nitrogen

Table 4.16(b). *Influence of leaf position/fraction on average leaf nutrient contents*

Per cent Nutrient content	Leaf position							Jats			
	Bud	1st leaf	2nd leaf	3rd leaf	4th leaf	5th leaf	6th leaf	Petiole	Internode	CD at 5%	Level of significance at P<
Nitrogen	3.08	2.56	2.50	2.12	2.00	1.95	1.94	1.71	2.22	0.14	0.001
Phosphorus	0.35	0.29	0.30	0.29	0.23	0.21	0.22	0.22	0.33	0.03	0.001
Potassium	1.72	1.80	1.88	1.90	1.92	1.81	1.79	1.91	1.91	—	NS
Calcium	0.41	0.47	0.59	0.70	0.75	0.76	0.81	0.84	0.61	0.06	0.001
Magnesium	0.21	0.23	0.22	0.22	0.22	0.22	0.21	0.24	0.27	0.20	0.001
Zinc (ppm)	68.85	49.75	45.20	45.05	43.25	42.95	43.10	52.08	82.57	3.17	0.001

and phosphate. Zinc content of petiole is comparable to those of leaves from first to sixth position. Internode contained generally high quantities of nutrients, specially Zn, Mg, K and P.

TECHNIQUE AND ANALYSIS

Redox Potential (Eh) of soils

Measurement of Eh using platinum and a reference calomel electrode in a ferrous⇌ferric ($Fe^{++}\rightleftharpoons Fe^{+++}$) system adding potassium dichromate as an oxidising agent has been standardised in the laboratory. Changes of Eh with addition of oxidising agent is shown in Fig. 4.10. The equilibriun point of $Fe^{++}Fe\rightleftharpoons^{+++}$ system has been found to be at Eh value of + 620 (see middle of inflexion point in Fig. 4.10. The method will be used to measure redox potential (Eh) of soils under varying intensity and duration of submergence.

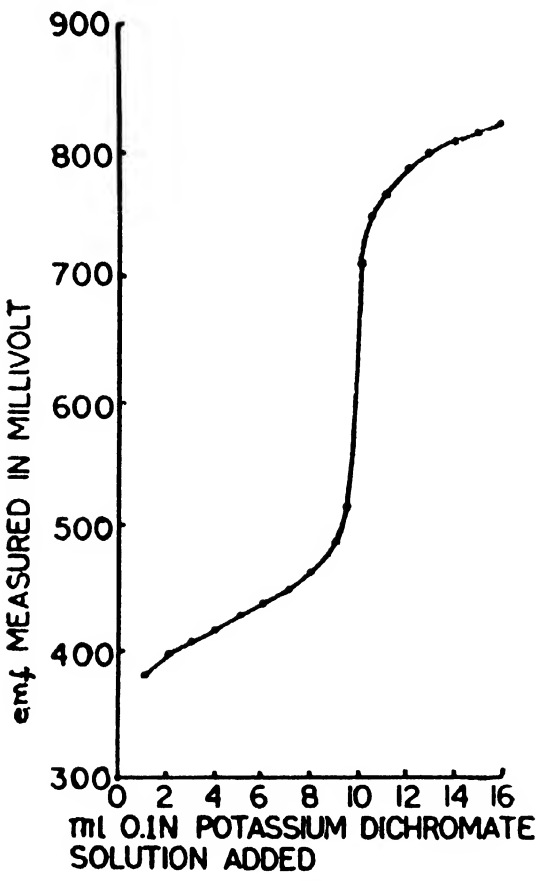


Fig 4.10. Potentiomertic titration of Fe^{++} solution with 0.1N $K_2Cr_2O_7$ solution using Pt electrode with Calomel standard 20 C

Soil moisture measurement of neutron moderation

A "well" type geometry had been accepted for calibration of the Neucleonic Moisture Gauge. Cylindrical drums were filled in with soil and sand in varying proportions and wetted thoroughly; thereby, different moisture regimes of different drums were maintained. Holes were made in different drums and casing of hole was made with thin-walled aluminium tube. The neutronprobe (source-counter assembly) was then inserted in these holes at selected depths and neutron counts recorded. Simultaneously from the same depths, soils were collected for determining gravimetric moisture content in a drying oven. Corrections were made for background noise in each measurement. Fig. 4.11 shows the relationship between gravimetric moisture content and neutron counts as shown by Gamma Ray Spectrometer.

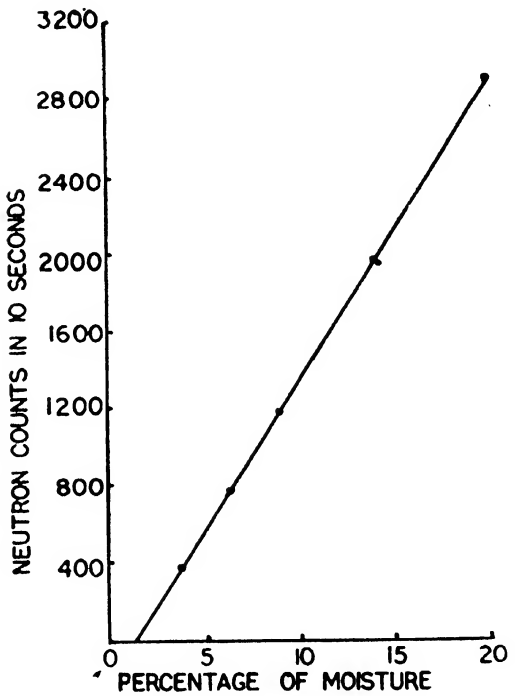


Fig 4.11. Relationship between gravimatic moisture content and neutron counts as shown by Gamma Ray Spectrometer

This *in situ* method will be used for instantaneous monitoring of the changes in moisture content of soil profile over a desired period, without resorting to disturbed sampling for gravimetric measurement of moisture.

Studies on Ground-water Drainage Problems

The work on "diagnosing the sub-soil drainage problem and developing a suitable drainage system for a given condition" initiated under UNDP has been extended to 13 gardens covering 31 sections by the end of year 1977-78.

A set of specially designed piezometers has been installed in each section to fulfil the main objectives mentio-

ned in the last Annual Report (Ann. Sci. Rept. 1976-77, p. 30). The observations on water table (W.T.) in the piezometers are plotted to give the water table elevations in between the two drains and along the drain. Similar investigations are being planned for a few other estates in Dibrugarh, Sibsagar, Dooars and Cachar.

The investigations are being carried out to evolve solution to the groundwater problem. The results obtained so far are summarised below :

Water-table, rainfall and drain discharge relationship

The studies on water table as influenced by the incoming rainfall were carried out at Tocklai, Hunwal, Ducklingia, Meleng and Haroochara Tea Estates. It was observed that the main drain discharge and the water table position responded very quickly to the incoming rainfall. A comparison of drainage-wise "poor" and "good" section showed a difference of about 50 cm in water table height.

The results presented in Fig. 4.12 show that the rainfall, drain discharge, and the water table position maintained a good agreement. Higher the rainfall rate, higher the drain discharge and higher was the water table. It was further observed that corresponding to rainfall rate of 60 mm/day, the maximum drain discharge obtained was 20 mm/day, which was taken as the drainage coefficient for Assam conditions. Similarly the drainage coefficient for Dooars area was chosen as 35 mm/day.

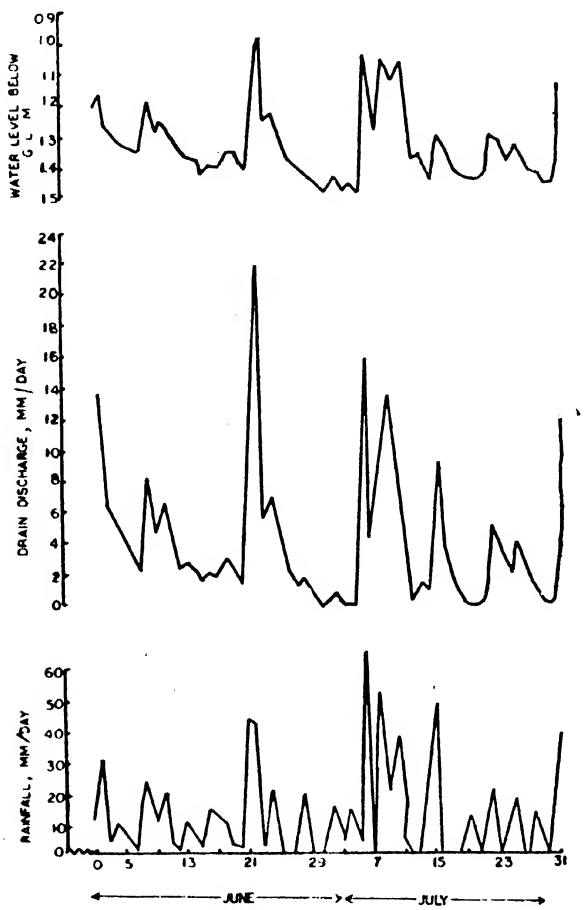


Fig 4.12. Relationship between water table drain discharge and rainfall

Effectiveness of deep drainage system

The experimental results have shown that by increasing drain depth from 57 cm (open ditch) to 150 cm (pipe drain), the depth to which the water table could be lowered was also increased considerably. The difference between the two was observed to be about 100 cm (Fig. 4.13). However, the most economic drain depth, which is a function of several other variables, needs to be investigated for which experiments have already been undertaken.

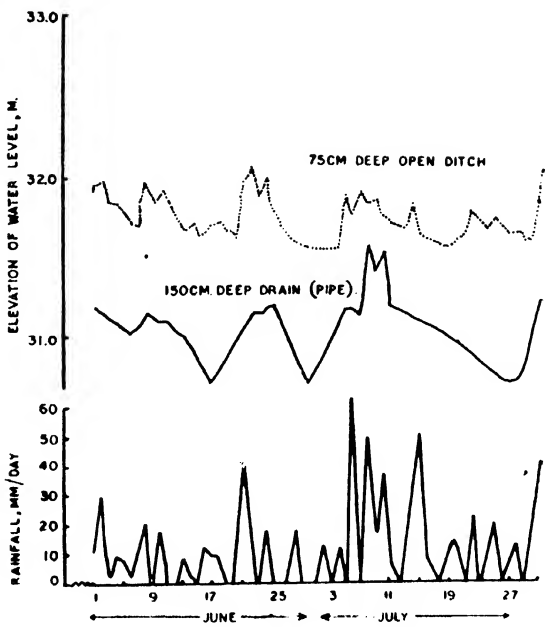


Fig 4.13. Rainfall-water table relationship as affected by depth of drain

Water table configuration along and between the two drains

These extensive investigations have been reported at length in the 28th Tocklai Conference. These may be summarised as follows :

(i) The water table follows nearly the shape of the land surface ;

(ii) the water table between the two drains takes the conventional eliptic shape. This provides the information regarding mid-point water table height which is important in drainage design for a given areas.

Effectiveness of pump outlet

An overall drainage improvement for a large catchment with restricted outfall at Haroocharai T.E. was taken up involving improvement of main collector and secondary drains. It also included a pump installation at the outlet, since outfall was found to be lower than the highest flood level (H.F.L.) of the river during peak rainfall periods. It was observed that in an area with restricted outlet, pumping the excess water provided satisfactory drainage conditions.

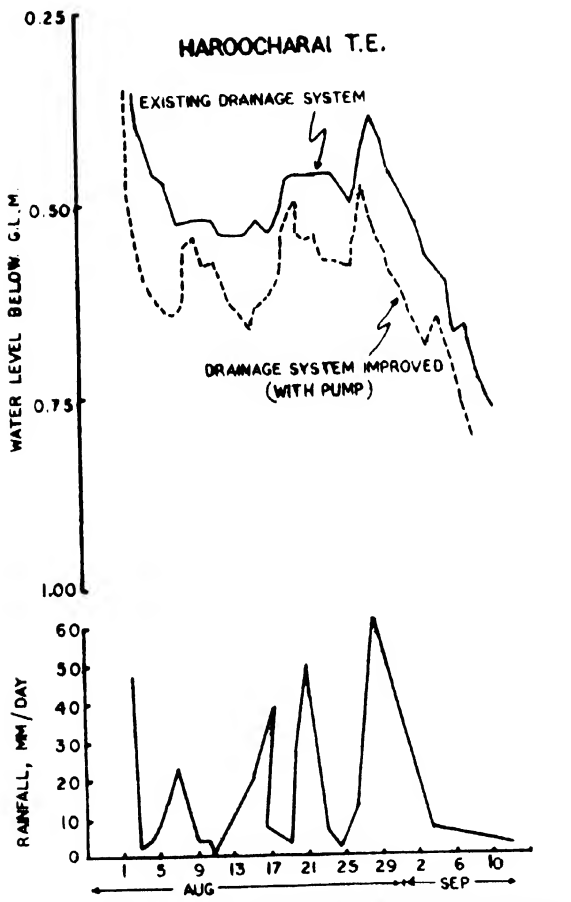
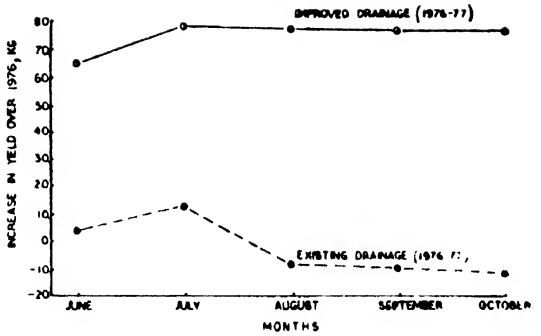


Fig 4.14. Effect of improved drainage system (with pump) on water table

The results presented in Fig. 4.14 indicate that in case of existing drainage system (no pump), the water table remained near the soil surface, whereas, in case of pump outlet, the water table could be lowered by about 55 cm below the soil surface.

The effect of pump drainage on yield is plotted in Fig. 4.15 which shows that after July, when the yield in non-pump area was decreasing, the yield in pumped area increased considerably.

Pump drainage system is now being tried out in Dibrugarh District at Lengrai T. E., where outlet is restricted.



ig 4 15. Per cent increase monthly yield over 1976 due to improved drainage (with pump)

Tentative design of drainage system for Dooars and Assam area

Table 4.17. *Tentative design criteria for drainage in Assam and Dooars*

Soil permeability K m/day	Assam		Dooars
	Pipe drain (D) meter	Drain spacing (S) meter	Drain spacing (S) meter
0.5	1.5	15	10
1.0	1.5	20	17
2.0	1.5	40	30
4.0	1.5	60	50

Drainage coefficient "q" for Assam = 20 mm/day.
Drainage coefficient "q" for Dooars = 35 mm/day.

These designs are being tried out in a number of estates

In addition, an experiment has been laid out on various depths and spacings of sub-surface pipe drains to find out the most economic depth and spacing.

Other investigations regarding drainage

(a) Soil permeability—The permeability has been determined *in situ* at Tocklai, Ducklengia, Hunwal, Haroocharai and Meleng T.E. The study is being extended further. The results obtained so far indicate the permeability value in the range of 1.5 to 2.5 m/day with an average of 2m/day for undisturbed sub-soil layers below the water table. And the same has been used in developing the tentative design of drainage system for Jorhat area.

(b) Depth of impermeable layer—The observations on the existence of an impermeable layer were made at sites where the auger holes were made to determine permeability. At almost all the sites, no clear cut clay layer could be located, but a denser layer was observed at a depth of 3 to 4 m below the soil surface. For Jorhat area, the depth of impermeable layer for computation purposes has been taken as 3 m and the same is used for calculating the drain spacing. The investigations on the depth of impermeable layer are being intensified further.

Research and Advisory Soil analysis

A total of 90,000 soil tests were carried out during the year, The break-up is as follows :

1 Research : 14,000 estimations

2 Advisory : (a) Tocklai : 56,000 estimations
(b) Dooars : 20,000 estimations

Meteorological Data

Meteorological observations were carried out throughout the year in six class "A" observatories, namely Tocklai, Thakurbari, Silcoorie, Nagrakata, Gungaram and Nagrifarm stations. Data have been processed, E.T. values by Penman's method calculated and summarised in Appendix D of this report. Besides cumulative moisture deficits for the period November'76 to April'77 have been estimated based on rainfall and open pan evaporation data collected from eight T.R.A. installations (Data reported in Appendix D).

Pollination studies carried out over the years revealed that tea generally is self-sterile. Cross-compatibility was high in both intra and inter-varietal crosses. Cambod variety gave good results both as male and female parents. Assam variety was best as pollen parent, and the reverse was true of the China variety.

Three clones have been provisionally selected for release to the industry. They will be released as soon as sufficient nucleus area could be established.

Under the Clonal Selection Scheme in the estates introduced in 1975, 84 estates have been surveyed so far, covering about 5000 ha of tea. 2650 mother bushes have been selected for trial.

Four clones from the first Long-Term Trial established under the scheme, appears to be promising for certification.

Driunal variatation in dry matter contents of plucked shoot between 8 a.m. and 2 p.m. showed that dry matter accumulation is rapid in the early hours.

Growth room experiment with high night temperature of 20° ± 2°C during the short-day winter months showed that it is possible to force bud-break much earlier, and that the plants completed one flush of growth by the time bud-break was observed in the control plants outside. The flush produced was quite normal and comparable to the first flush of the spring growth.

Growth regulator studies indicated the possibility of obtaining early flush by foilar spraying of GA_3 at 100 ppm, and by suppressing rains crop for two/three weeks by retardants like Ethephon at 100 ppm without affecting the total crop. However, clones varied in their response.

Radiotracer studies show that pluckable shoots are the strongest sinks of photosynthates and even GA_3 treatments could not change the situation. No movement of metabolites from two leaf and a bud shoot was observed upto three days.

PLANT IMPROVEMENT

Biclonal Stock Trial

The biclonal stock trial with seven stocks (Ann. Rep. 1976-77, p. 32) was continued during the year. Five stocks appear to be better in yield and quality than Tocklai Biclonal Stock 449. The trial of the stocks in the Dooars and Cachar also confirms the promising nature of these stocks. Encouraging reports on these stocks have also been received from the observation plots set up in different agro-climatic regions.

It is hoped that a decision on the release of the new stocks will be possible by the end of the 1978-79 season.

Micro-seed baris

Three micro-seed baris selected earlier on the basis of pollination results and short-term trial of hybrid, seeds were planted out during the year. Generative clones of a few more biclonal combinations were propagated during the year for establishment of micro-seed baris.

The two micro-seed baris established in 1975 (Ann. Rep. 1975-76, p. 28) are expected to produce sufficient seeds for trial in 1978-79 season.

Pollination results

Since the inception of the Botany Department in 1930 a large number of pollinations were carried out in different varieties of tea. A summary of forty years' results was published in *Two and A Bud* **24**:*21-26* (*1977*).

Tea, in general, was found to be self-sterile. However, "individuals of a variety" varied in their self-in compatibility. Some clones were observed to produce as high as 10 per cent fruit set from selfing. In general, self-compatibility was high in the Cambod variety and low in the China variety, the Assam variety being intermediate in position.

Cross compatibility was common in both intra and inter-varietal crosses, but certain crosses were found to be completely incompatible. While the Cambod variety produced equally good results as male and female parents, the Assam variety was found to be the best as pollen parent and worst as female parent and the reverse was true of the China variety.

A few related species were also found to be compatible with tea.

Selection of vegetative clones

Eighteen bushes were selected from a section of China hybrid tea on the basis of their quality and yield. The bushes will be put to rooting trial in the next season.

Long-term trial of clones

At present, about 130 clones are in various stages of long-term trial. Out of the three trials started in 1971, three clones have been provisionally selected for release to the industry. The clones will be released as soon as sufficient number of nucleus bushes could be established at Tocklai and the sub-stations.

In other long-term trials, some more clones are showing promise.

Selection of clones in tea estates

The clonal selection work in the tea estates was continued during the year. The area screened and the number of bushes selected are shown in table 5.01.

This brings the total to 84 estates surveyed from the beginning of the scheme covering approximately 5000 ha of tea, from which 2650 mother bushes were

Table 5.01. *Summary of clone selection in estate*

Region	No. of estates	Area surveyed (ha)	Bushes selected
Assam, South Bank	21	857	981
Dooars	4	281	182
Darjeeling	1	20	27
Total	26	1158	1190

selected. Follow-up measures were continued in all the areas. Unfortunately, however, some of the estates could not carry out the scheme according to the schedule.

The first long-term trials under the scheme were established at Heeleakah T.E. in 1975 and 1976 with nine and seven clones, respectively. Four clones from the first trial and two clones from the second trial appear to be promising. A long-term trial was also started at Dahingeapar T.E. in 1977 with nine clones. A few more trials will be started this year in different regions.

PLANT PHYSIOLOGY

Dry matter content

In continuation of the previous investigations on diurnal and seasonal variations in per cent dry weight of plucked shoots (Ann. Rep. 1976-77, pp. 33-35), another statistically designed experiment was conducted this year. This experiment was on pruned tea (the previous investigations were on unpruned tea) and included all the clones of the previous investigations except TV 3. Plucking was done at 8 a.m, 11 a.m. and 2 p.m., one third of the bush being plucked each time. Results presented in Table 5.02, show that dry matter increased with time of plucking from 8 a.m. through 11 a.m. to 2 p.m. The rate of increase varied between time intervals, and between clones, as reported previously. The rate of dry matter accumulation in plucked shoots of all the three clones is significantly higher between 8 a.m. and 11 a.m. than between 11 a.m. and 2 p.m. The seasonal average dry matter of shoots plucked at the three different hours of day is shown in Table 5.03.

Table 5.02. *Per cent dry weight of shoots of three clones plucked at 8 a.m., 11 a.m. and 2 p.m. (mean of 3 repeats)*

Date of plucking	% dry weight 8 a.m.	11 a.m.	2 p.m.	Difference between 8 & 11 a.m.	11 & 2 p.m.
Clone TV 9					
20-6-77	20.35	23.38	24.22	3.03	0.84
6-7-77	20.11	22.73	24.28	2.62	1.55
20-7-77	22.87	23.91	23.85	1.04	-0.06
3-8-77	22.47	23.24	22.84	0.77	-0.40
31-8-77	21.59	22.43	23.25	0.84	0.82
28-9-77	22.09	22.57	23.80	0.48	1.23
12-10-77	21.23	22.80	23.31	1.57	0.51
9-11-77	19.33	21.69	22.12	2.36	0.43
23-11-77	20.55	21.89	21.78	1.34	-0.11
Average	21.18	22.51	23.28	1.33	0.77
Clone TV 11					
20-6-77	22.05	23.93	23.24	1.88	-0.69
6-7-77	20.01	22.54	23.09	2.53	0.55
20-7-77	22.55	23.68	21.84	1.13	-1.84
3-8-77	24.49	23.58	24.22	0.09	0.64
31-8-77	22.12	22.80	23.38	0.68	0.58
28-9-77	22.26	23.21	24.36	0.95	1.15
12-10-77	21.00	21.33	21.86	0.33	0.53
9-11-77	19.28	22.18	22.66	2.90	0.48
23-11-77	21.86	22.18	22.34	0.32	0.16
Average	21.62	22.82	23.00	1.20	0.18
Clones TV 16					
20-6-77	20.22	23.53	23.52	3.31	-0.01
6-7-77	18.51	22.36	22.81	3.85	0.45
20-7-77	21.18	23.08	22.68	1.90	-0.40
3-8-77	22.52	23.31	23.88	0.79	0.57
31-8-77	21.23	21.78	22.34	0.55	0.56
28-9-77	21.18	23.36	23.53	2.18	0.17
12-10-77	19.98	20.31	20.98	0.33	0.67
9-11-77	18.11	22.26	22.66	4.15	0.40
23-11-77	20.75	21.80	21.62	1.05	0.18
Average	20.41	22.42	22.67	2.01	0.25
Overall mean	21.07	22.58	22.98	1.51	0.40

Table 5.03 *Percent dry weight of shoots of different clones plucked at three different hours of the day from June to November.* (mean of 27 observations, 9 plucking dates x 3 repeats)

Clone	Plucking time 8 a.m.	11 a.m.	2 p.m.	Percent increase 8 a.m. to 11 a.m.	11 a.m. to 2 pm.
TV 9	21.18	22.51	23.28	6.10	3.42
TV 11	21.62	22.82	23.00	5.55	0.79
TV 16	20.41	22.42	22.67	9.85	1.12
Mean	21.07	22.58	22.98	7.17	1.77

The mean per cent increase over the season at 11 a.m. over 8 a.m. varies between clones from 5.6 to 9.9 while the increase between 11 a.m. and 2 p.m. varies from 0.8 to 3.4 per cent. Increase per hour, when all the clones are taken together, is 2.4% between 8 a.m. and 11 a.m. compared to only 0.6% between 11 a.m. and 2 p.m. suggesting that the accumulation of dry matter is more rapid in the morning than in the afternoon.

Per cent dry matter content of shoots plucked at three different hours of the day for the three clones is shown graphically in Fig. 5.01.

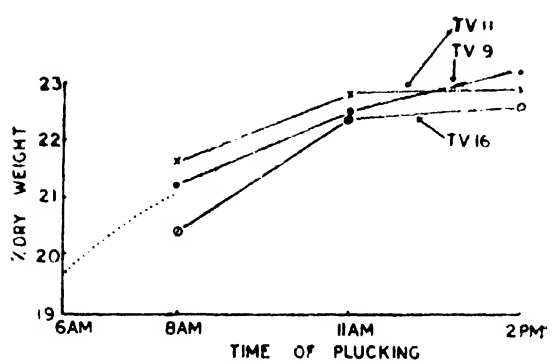


Fig 5.01. Per cent dry matter of shoots plucked at different hours of the day

If the line representing the average is extrapolated to 6 a.m. (since plucking generally starts from 6 a.m. IST in tea estates), the increase of dry matter between 6 a.m. and 11 a.m. would be about 12%. However this method of representing dry weight as percentage of fresh weight does not take into account the increase in fresh weight of the whole shoot during the obervation period (Increase in area does not require consideration since the data are not based on leaf area basis). Had this also been taken into consideration, the actual rate of dry matter accumulation between 6 a.m. and 11 a.m would have been more than 12%.

In the light of these findings, a large scale field experiment has been started. Besides yield recovery percentage at the drier-mouth and cup characters of made tea will also be examined.

Dormancy

The phenomenon of winter dormancy in tea in N.E. India has been studied systematically for the last few years. Results obtained so far lead us to conclude that winter dormancy is due to an interaction between short day length and low night temperature, which in turn, disturbs the hormonal balance. The buds resume growth only after restoration of the proper balance between growth promoting and growth retarding substances, either by exogenous application, or by endogenous production of growth promoters like gibberellic acid.

Based on the information available, an experiment was started in winter to study the effect of high night temperature on growth of terminal and axillary buds of one year old pot grown plants. Ten plants, each of clones TV 1 and TV 20, were kept in the growth room from 4th December '77 to end-February '78 under controlled conditions of temperature and humidity. The temperature of the growth room was maintained throughout at 20 ± 2°C from 7p.m. to 7a.m. i.e. similar to night temperature during summer. Another group of 10 plants, each of the two clones, were kept outside as control.

The plants in the growth room started bud-break much earlier and completed one flush of growth by the time bud break was observed in the control plants (Table 5.04). Figure 5.02 shows the difference in growth of the plants after 78 days of treatment.

It can be seen from the data in table 5.04 that the terminal buds on the main stem of both the clones exposed to high night temperature started growth much earlier than the plants in the controlled series.

Bud break took place earlier in clone TV 20 than in TV 1 both in the treated and control plants ($P < 0.01$) The earliest bud-break in TV 20 was noticed within about three weeks from the transfer of the plant to the growth room, whereas TV 1 plants remained dormant for more than four weeks.

Fig 5.02. Difference in growth of the plants after 7 days of treatment
Left—Treated
Right—Control

Table 5.04. *Number of days taken by the terminal and axillary buds of treated and control plants to start growth*

Plant Pairs	Clone TV 1		Clone TV 20	
	Treated	Control C	Treated T1	Control C1
1	61.1	86.5	55.5	74.5
2	67.3	88.8	54.9	78.7
3	59.5	98.2	59.7	79.0
4	64.3	88.9	46.0	84.3
5	58.5	84.7	56.5	79.0
6	62.2	86.8	53.0	79.2
7	66.0	97.5	41.3	85.5
8	63.4	88.6	47.0	78.0
9	62.7	77.7	29.0	82.0
10	62.0	91.6	40.5	79.5
Mean	62.7	88.9	48.3	80.0
S. E.	±0.9	±1.9	±3.0	±1.0

To complete one flush i.e. the first flush of the season, the plants in the growth room at high night temperature took about four to five weeks. The control plants kept outside the growth room and which started flushing about a month later also took about the same time to complete the flush.

Although the treated and control plants differed in the starting and completion of the first flush, practically no difference was observed in the production of number of laterals, leaves and size of the flush when completed.

Growth regulators on bud-break in tea

Observations on bud-break of clone TV 9 by foliar spray of different growth regulators like 4-CPA, auxin GA_3 gibberellins, BA, cytokinin and growth retardants like CEPA, SADH and CCC were reported last year

(Ann. Rep. 1976-77). Further observations on the production of number of laterals and primaries produced were continued during the year. Samples were also manufactured by the CTC method and made teas were evaluated by tea tasters. None of the treatments had any effect on the number of primaries or laterals produced, and cup characters of made tea.

Growth regulators on crop distribution

Preliminary observations of the effect of different growth regulators on crop distribution in three unreleased clones were reported last year (Ann. Rep. 1976-77, p. 35). Observations were continued during the year on Tocklai clones TV 7, TV 15 and TV 18 representing Chinary, Assam and Cambod types. Some of these observations were reported at the 28th Tocklai biennial scientific conference and published in the proceedings of the conference. (Proc. 28th Tocklai Conf. pp. 41-43, 1977). Feasibility of getting early flush by foliar spraying of GA_3 at 100 ppm and suppressing the rains crop by retardants like ethephon (CEPA) at 100 ppm for two or three weeks without affecting the annual crop or quality of made tea was indicated.

The experiment is being continued this year, adding two more clones i.e. TV 9 and 107/16, advancing the time of application and reducing the concentration of gibberellic acid, but repeating spraying at monthly intervals from January 1978. It was observed that spraying in second week of January did not help production of early flush. Second week of February seems to be the earliest possible time of application to induce early flushing. Among the two gibberellins GA_3 and GA_{4+7} tried, GA_3 seems to be more effective than the GA_{4+7} for production of early flushes, provided soil moisture is not limiting (Fig 5.03). Clones varied in their response to growth regulators. Further investigations are in progress.

Fig 5.03 Gibberellins on early flushing in TV18 middle row control

Growth retardants on rooting of cuttings

Growth regulator solutions were sprayed in April 1976 on TV 13 mother bushes at Borbhetta. Cuttings from the sprayed bushes were propagated in July and November 1976, and observed for rooting. The sprayed bushes were examined in 1977 for residual effect, if any, and for shoot production. Cuttings were propagated again during June 1977, the year following spraying to varify effect on the rooting of cuttings.

Spraying each of indolebutyric acid (IBA) at 200 ppm, morphaction IT-3456 at 100 ppm, and CCC, CEPA and SADH at 1000 ppm consistently increased the number of better rooters over the control at every propagation. It was observed that the treated mother bushes produced normal shoots in the subsequent year and no phytotoxic effects or die-back could be seen. Use of IBA and the retardants for improving rooting of cuttings is a possibility that needs further confirmation.

Growth regulators to induce branching in young tea

Centering of young tea using a knife involves removal of growth. If the desired branching can be achieved by spraying growth retardants alone or in combination with such a practice as pegging, the loss of growth can be minimised.

With this objective in view studies were initiated in the field on three clones TV 1, TV 18 and T_3 E/3 using Cycocel (CCC), alar-85 (SADH), (N.C. 963) (Fison U.K.), ethephon (CEPA), PP. 528 (ICI, UK) and GA_3, in three concentrations to study their efficacy in checking the terminal growth and promoting development of laterals. Pegging was used as control. Some indication of growth suppression and promotion of laterals was obtained with certain retardants. These studies are being continued.

PHOTOSYNTHESIS AND TRANSLOCATION STUDIES USING C^{14} ISOTOPE

Distribution of photosynthate from the maintenance foliage

The role of maintenance foliage in nourishing the pluckable shoots is well known. However, the factors that control the distribution of photosynthates from the maintenance foliage are yet to be elucidated. Experiments were, therefore, initiated on field-grown mature bushes using labelled $C^{14}O_2$ and the observations based on autoradiographs are reported here. The set up used to expose the leaves with labelled carbon dioxide ($C^{14}O_2$) is shown in Fig. 5.04.

Each primary shoot on a pruned and plucked bush, used in the experiment, had three axillary shoots each supported by a maintenance leaf. Two such shoots were selected and one maintenance leaf of each shoot was exposed to 30 μc of labelled carbon dioxide for an hour. The terminal portions of the axillary shoots of

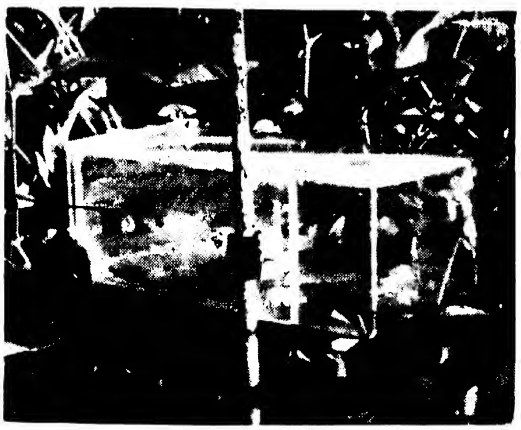


Fig 5.04. Set up Showing Plexiglasis chamber for exposing intact leaves in the field to Co_2

one primary were treated with gibberellic acid (GA_3) at 100 ppm. The axillary shoots on the other were left untreated as control. The shoots were left undisturbed overnight to allow time for translocation of the photosynthates, and were harvested next morning.

The autoradiographs show that the photosynthates moved from the maintenance foliage, more towards a vigorous terminal flush above, than to the less vigorous lateral flushes on the sides (Fig 5.05). Although all the three shoots in the branch were treated with gibberellic acid, the middle shoot showed the presence of more tagged photosynthates than the remaining two shoots (Fig 5.06). Hence, a vigorous, developing shoot is a stronger 'sink', importing more photosynthates from the source (maintenance leaf) than the other weaker and banjhi shoots. The developmental stage, rather than the proximity of the shoot to the source, appears to control the import of photosynthates from the maintenance foliage. Acropetal movement of photosynthates seems to be preferred.

Hormones are involved in regulating the partition of photosynthates from the maintenance foliage. GA_3 solution creates a temporary sink. In order to verify this, an experiment was undertaken. In a mature plucked bush in the field, a shoot with maintenance foliage was selected. Two randomly selected maintenance leaves were treated with GA_3 solution and later exposed to $C^{14}O_2$. The shoot was harvested next day and autoradiograph was examined (Fig 5.07). Despite the treatment of the maintenance foliage with GA_3 solution, photosynthates moved into the pluckable shoots originating from the axil of the treated leaves. No movement of photosynthates to the axillary shoot below the treated leaf was observed, although traces of photosynthates were seen in an axillary shoot above (acropetal) the treated leaves. There seems to be a relation between the phyllotaxis and the acropetal distribution of photosynthates. The pluckable shoots appear to exert a pulling force on the metabolites.

Comparison of TV clones for rate of translocation of photosynthates

Productivity of a clone depends on many factors, of which the rate of photosynthesis and translocation of photosynthates are principal ones. Experiments were intiated on one year old pot grown TV 1 and TV 20 plants using $C^{14}O_2$. Mature, fifth leaf from the apex, was exposed to $C^{14}O_2$ around 11 a.m. in the sun. The plants were uprooted at hourly intervals and processed for autoradiographs.

It was observed that there is a time lag of at least one hour between the time of CO_2 fixation and the movement of the metabolites (photosynthates) out of the exposed leaves, the rate of translocation being about 15-20 cm per hour. Further studies are in progress.

Photosynthesis and translocation in two and a bud shoots

Studies on dry matter content of plucked shoots indicate that more crop can be harvested if plucking is done in the afternoon rather than in the morning hours. There were apprehensions whether the delay in plucking would result in the loss of dry matter through the export of photosynthates. To verify this phenomenon, studies were undertaken using one year old pot grown TV 20 plants. The pluckable two and a bud shoot in each plant was exposed to $C^{14}O_2$ and allowed to photosynthesise in the day light. The shoots were harvested 6 hours and three days later and autoradiographs prepared (Fig 5.08).

It was found that no photosynthates moved out of the pluckable, two and a bud shoots, even after three days. The two and a bud remains as a sink importing metabolites from the maintenance leaves besides producing some photosynthates by itself. It does not export metabolites to other leaves. Therefore delays in plucking upto a few days should not atleast in theory cause any loss of dry matter of the pluckable shoots.

Fig 5.05. Cover transparency : Mounted specimen TL— Maintenance leaf exposed, to $C^{14}O_2$

Fig 5.05. Autoradiograph. Note the distribution of $C^{14}O_2$ labelled photosynthates presence of labelled $Cc^{14}O_2$) photosynthates appears as dark spots in the autoradiographs

Fig 5.06. Cover transparency : Mounted specimen TL Maintenance leaf exposed to Co_2 GA_3 Shoots treated with gibberellic acid

Fig 5.06. Autoradiograph. Note the movement of photosynthates

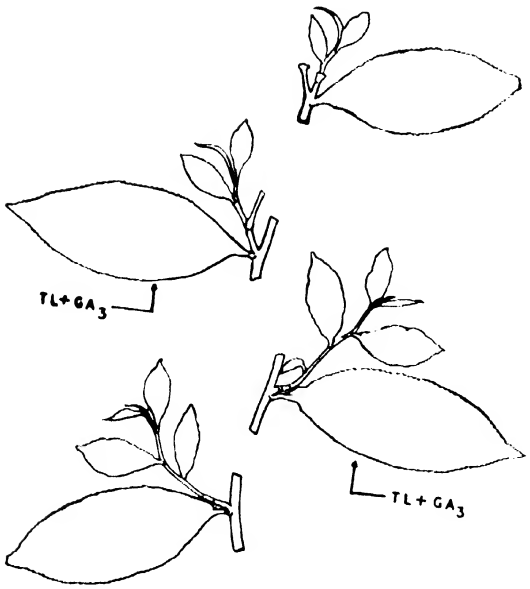


Fig 5.07. Cover Transparency : Mounted Specimen TL+GA_3=Maintenance leaves treated with GA_3 and Exposed to $C^{14}O_2$

Fig 5.07. Autoradiograph. Note the distribution of photosynthate to axillary shoots

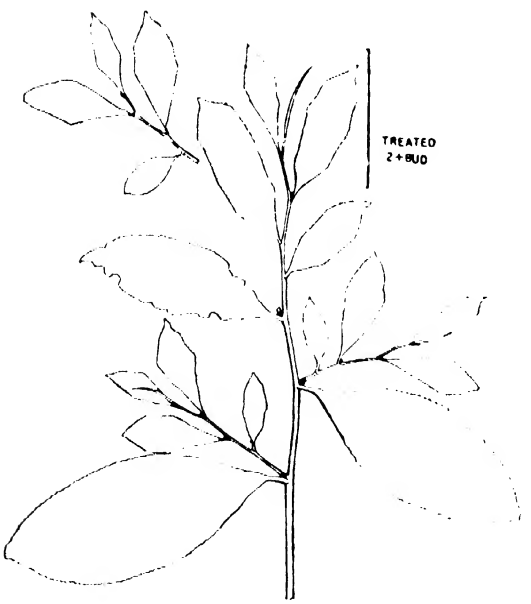


Fig. 5.08. Cover Transparency : Mounted specimen showing exposed two leaf and a bud to $C^{14}O_2$

Fig 5.08. Autoradiogrsph. $C^{14}O_2$ fixed; No photosynthate moved out of the pluckable (2 + bud) shoot

Besides Xyleborus fornicatus, *reported last year, two more species of Shot hole borers have been reported. Fecundity of scarlet mite is highest on TV 13 and least on TV 20. Microclimate within the tea under shaded and unshaded conditions affect the distribution and abundance of tea mites. Pink mite incidence is more than purple mite on clones TV1-TV 19. Phenology of looper caterpillar has been worked out. Tea Helopeltis causes a loss of 30,000 kg of made tea from 135 hectares of young tea plantation. Damaging capacity of a single adult* Helopeltis *and its reproductive potentiality have been studied. Thrips incidence is on increase on skiffed teas than on pruned teas. Biological studies of two new scales have been made. Survey on shade tree pests have been made in the Dooars. Soil heating has definite killing effect on nematodes. Degree of infestation of root-knot eelworm is more in silty loam soil than in silty clay loam. A novel insecticide, Dimilin, appears to inhibit the growth of first instar looper caterpillars. Sumicidin and Bioresmethrin appear to be highly lethal even at a dilution of 1:8000 and are therefore considered highly promising insecticides. Six commercial formulations of acaricides, twelve insecticides and four nematicides have been evaluated against pest complex.*

BIOLOGY OF MITES

A. Clonal susceptibility of mites : An idea of the susceptibility of clones TV16, TV17, TV18, TV19 and TV20 to scarlet mite *Brevipalpus phoenicis* (Geijskes) was obtained from its fecundity on these clones, maintained under comparable conditions i.e. at 19°C with 70% R.H. In this experiment mites were kept on randomly selected leaves from each clone. Although there was some variation in oviposition rate on leaves of different ages, in general, egg laying was highest on clone TV16 and lowest on clone TV17 and TV 20 in an unit time; the intermediate position being that of TV18 and TV19.

Life-cycle of scarlet mite at 30°C (Table 6.01) on these clones is completed in 20 days, with very little variation between clones. Therefore, though the level of mite infestations may vary on these clones, the time interval for the second round of palliative spray will remain nearly the same.

Table 6.01. *Fecundity and life-cycle of scarlet mite, Brevipalpus phoenicis (Geijskes) at 30°C*

Clones	Average number of eggs laid/ female	Average incubation period (days)	Average duration of life-cycle (days)
TV 16	6.0	5—6	19.3
TV 17	4.4	5—6	20.0
TV 18	5.0	6—7	19.8
TV 19	5.0	5—6	19.0
TV 20	4.0	5—6	20.0

Long term studies on the potential population build up of scarlet mite on clones TV6 to TV20 was assessed at 30-32°C, 75% R.H. as are common in the plains of north-east India during flushing period. The results indicate (Table 6.02), that egg laying is at maximum

Table 6.02. *Fecundity of scarlet mite, Brevipalpus phoenicis Geisakes, on clones at* 30-32°C with 75-77% *R. H.*

Clones	Average No. of eggs laid/female	Maximum oviposition period (days)
TV 13	20.2	21.0
TV 8	18.0	31.0
TV 10	17.0	22.0
TV 6	16.0	30.0
TV 14	15.0	23.0
TV 15	11.8	19.0
TV 12	10.2	15.0
TV 7	10.0	12.0
TV 16	6.0	7.0
TV 9	5.0	7.0
TV 11	5.0	6.0
TV 18	5.0	9.0
TV 19	5.0	6.0
TV 17	4.4	7.0
TV 20	4.0	5.0

on clones TV13, TV8, TV10, TV6, TV14, and is least on clones TV20, TV17, TV19, TV18, TV11, TV9, and TV16: the intermediate position being occupied by clones TV15, TV12 and TV7. The practical significance of this study is that adjacent planting of clones having a comparable degree of susceptibility will, in all probability, be highly conducive to rapid mite build up. Plantation of these clones will also require specific control of both eggs and adults at the very early stage of infestation.

B. Effect of microclimate on the incidence of mites in different zones of mature tea : Seasonal population cycle of Red spider, *Oligonychus coffeae* Nict., Scarlet mite, *Brevipalpus phoenicis* (Geijskes), Pink mite, *Acaphylla theae* (Watt) Keifer, and Purple mite *Calacarus carinatus* Green were studied from samples of mite population in the upper, middle and lower zones of mature bushes in shaded and unshaded areas.

Results, graphically presented in Figs 6.01 to 6.06, show a wide variation in the distribution of mites. Thus, in shaded tea Pink mite numbers were significantly high in the upper zone; Red spider in middle and lower zones; scarlet mite in lower zone, and purple mite in the middle zone of the bushes. In unshaded tea, Pink mite continues to be dominant in the upper zone; Red spider in the middle and lower zones, scarlet mite and purple mite mostly inhabit in middle and lower zones.

This investigation shows that waxing and waning of the mite numbers vary with species and interact with the specific microclimate within the bushes under shaded and unshaded conditions. These long term studies also show that notwithstanding their diverse habits, all the four species of mites could infest the same bush in varying numbers. It is also becoming

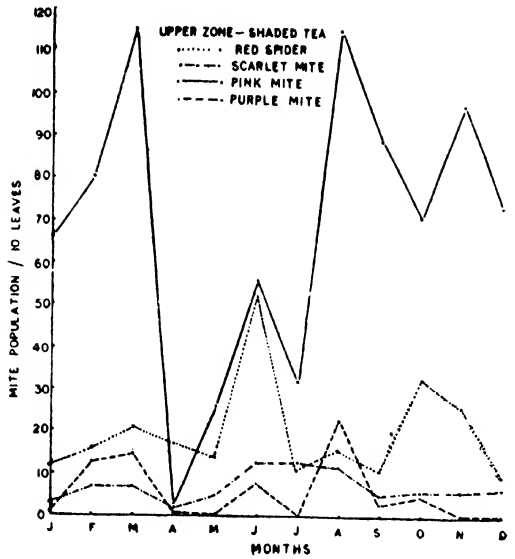


Fig 6.01. Incidence of mites on upper zone of shaded tea

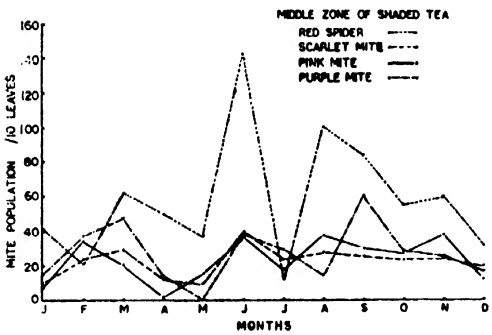


Fig 6.02. Incidence of mites on middle zone of shaded tea

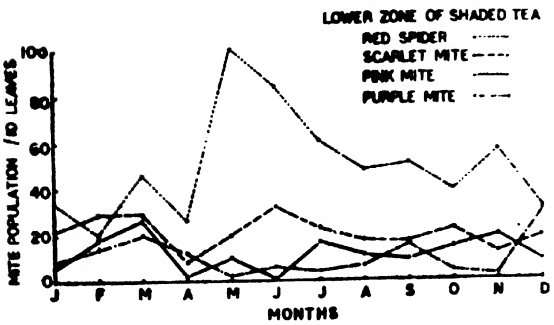


Fig 6.03. Incidence of mites on lower zone of shaded tea

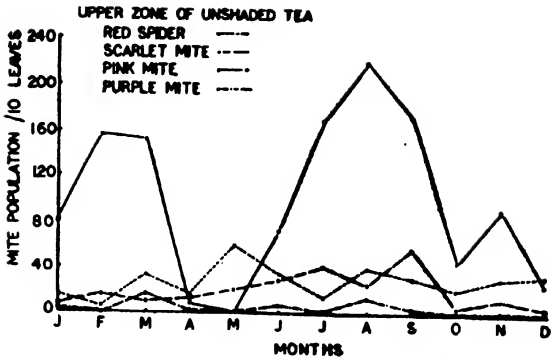


Fig 6.04. Incidence of mites on upper zone of unshaded tea

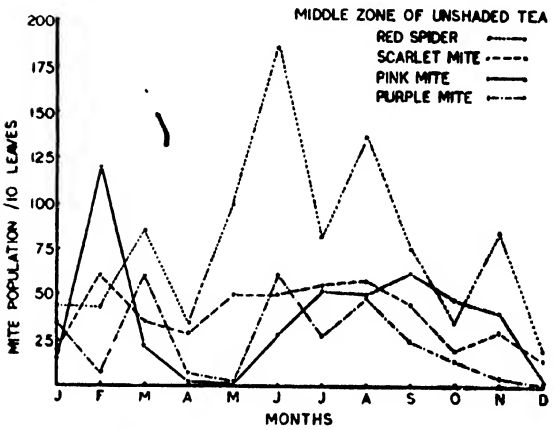


Fig 6.05. Incidence of mites on middle zone of unshaded tea

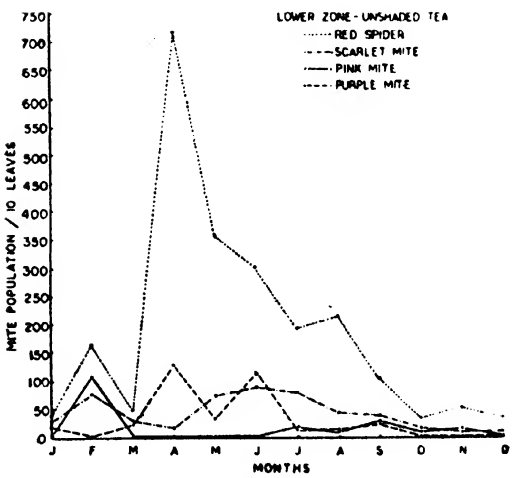


Fig 6.06. Incidence of mites on lower zone of unshaded tea

increasingly clear that pink mite could become the dominant mite under both shaded and unshaded conditions. Indeed, inspite of the variability in their absolute numbers, the trend of the population cycle of the four species of mites is nearly the same. It is thus possible that the four species react differently with the variation in microclimate in different zones of the bushes, though the level of response varies with the specific ecological requirement of each species. From a purely practical point of view, this situation calls for a quick acting broad spectrum acaricide that will act simultaneously on all damage causing stages of the four species of mite. Development of a sprayer system that will penetrate all the layers in a bush hamper is also appearing to be an urgent necessity.

C. Susceptibilities of Tocklai clones to pink and purple mites : In view of increased abundance of pink and purple mites, susceptibilities to Tocklai clones TV1 to TV 19 to these mites were assessed. The clones used in this study are comparable with respect to age and agromanagement practices. Mite incidence was recorded every month from 100 randomly selected leaves of each clone: the overall incidence at the end of main period of infestation on an unit of 10 leaves is shown in Fig. 6.07 and 6.08. Because of seasonal variation in the number of mites on each clone, a broad generalization is not possible, but as Figs 6.07 and 6.08 show, clone to clone variation in the number of these mites may not be as wide as in the case of red spider. It is interesting, however, that under identical conditions incidence of pink mite is high on each clone than that of purple mite.

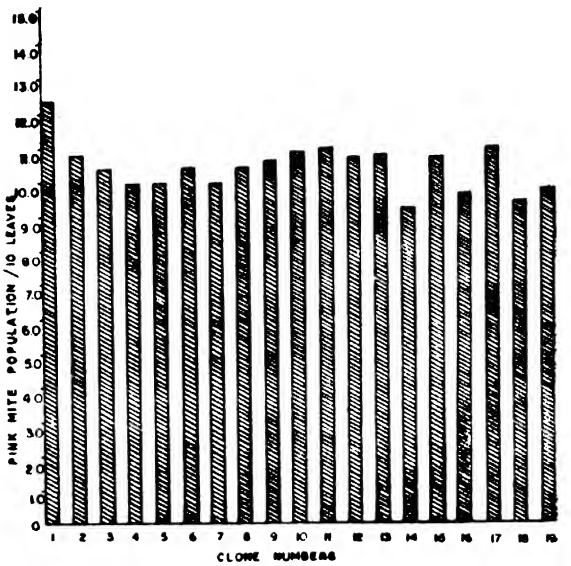


Fig 6.07. Susceptibility of Tocklai clones to Pink mite

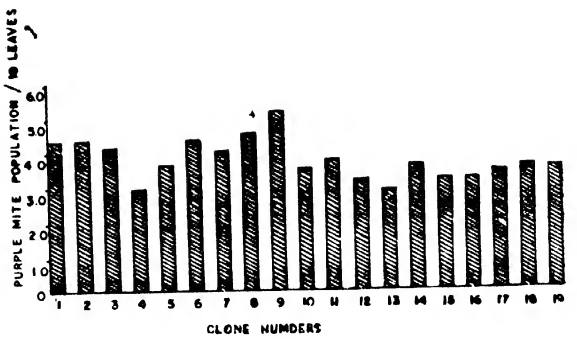


Fig 6.08. Susceptibility of Tocklai clones to Purple mite

D. Longer pruning cycle and mite incidence: Comparative assessment of the seasonal cycles of red spider, scarlet mite, pink mite and purple mite on tea under differential pruning cycle i.e. unpruned, top pruned, medium skiffed and deep skiffed, were made. Although the bushes under four cycles of pruning were not always comparable, it was possible to sample adequate number of uniform bushes under various cycle of pruning. Mite numbers varied and fluctuated characteristically with each species. On medium skiffed tea, red spider population reached its maximum in April at a level not achieved on bushes having other forms of pruning, but the second peak in November was almost of the same magnitude on all teas except the top pruned ones (Fig. 6.09). In the case of scarlet mite (Fig. 6.10) overall incidence

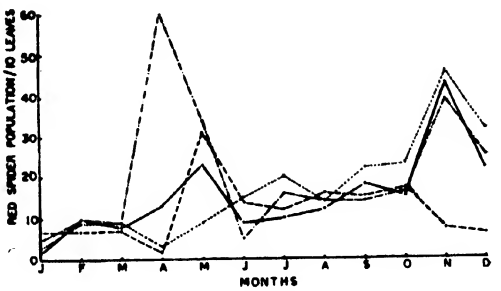


Fig 6.09. Susceptibility of Tocklai clones to Purple mite

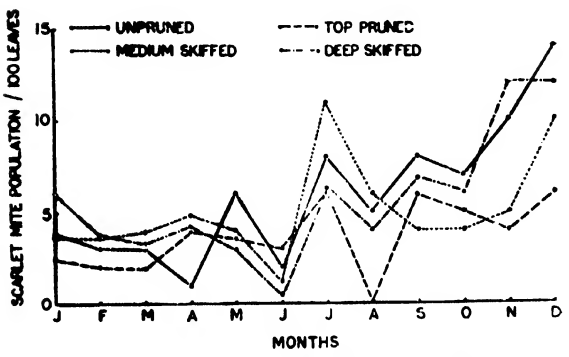


Fig 6.10. Incidence of red spider in relation to longer pruning cycle

was lesser than that of red spider, though the critical level was always maintained on all teas under differetial pruning. In common with red spider, the maximum in the summer and autumn peaks in this mite were well marked only in top pruned tea, while on the rest, a nearly steady population level was maintained.

Pink mite populations were remarkable for their wide variations (Fig 6.11) and the peak in July was at its maximum on unpruned tea, followed by deep skiffed, medium skiffed and top pruned tea in that

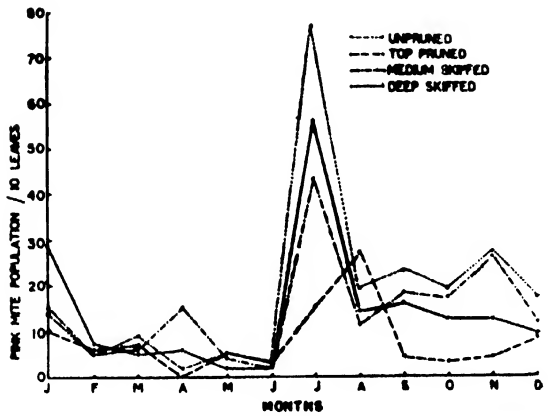


Fig 6.11. Incidence of pink mite in relation to longer pruning cycle

order. It is also interesting that pink mite population in general (except deep skiffed tea in January) was at low level of abundance, before July, and at a higher level after July. Curiously enough, for some inexplicable reasons, purple mite populations remained relatively at a lower level than other mites and it maintained a near steady level on all teas (Fig 6.12).

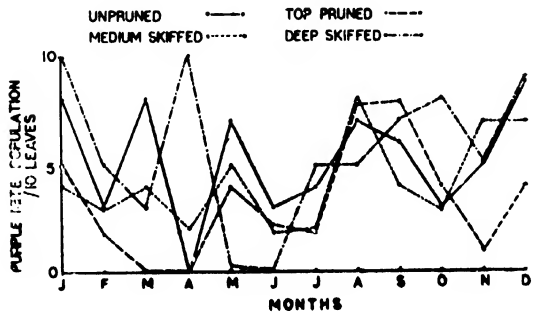


Fig 6.12. Incidence of purple mite in relation to longer pruning cycle

It is thus plausible that interactions between pruning cycle and the foliar volume resulting from various cycles, influence the dynamics of mite pest populations. Climatic factors could also intensify or reduce the effects of the pruning cycle on pest build up. This may require flexibility in the schedule of acaricidal spraying.

E. Effects of foliar applications of nutrients on incidence of mites : The effects of plant nutrients on the incidence of mites was assessed from 50 randomly selected leaves from each of the following treatments.

A. Urea @ 8 kg/ha
B. Potash @ 8 kg/ha (MOP)
C. Zinc ($ZnSo_4$) 5 kg/ha
D. Urea+Potash (4 kg+8 kg/ha)
E. Urea+Zinc (3 kg+5 kg/ha)
F. Control (No treatments)

Incidence of different species of mites was assessed from leaf samples drawn in April, July, August, September and December; the indications are :

1. Red spider—application of urea increased its infestation, while zinc and zinc+urea lowered the trend.
2. Scarlet mite—potash and zinc reduced the incidence.
3. Pink mite —urea, potash, urea+potash, and urea+zinc reduced incidence
4. Purple mite—urea, zinc and urea+zinc reduced incidence.

It must be noted that although nutrients reduced the incidence of mites, in no way did they control the mites; indeed the damaging level was persisting in all treatments. This study, however, shows that bush health may cause some reduction in the absolute numbers of mites, though how long the effect would last was not clear from this experiment.

TEA LEAF DEFOLIATOR

A. Looper caterpillars : The looper *Buzura (Biston) suppressaria* Guer is a major defoliator of mature tea. There is well marked variation in the duration of the life cycle of the pest (Table 6.03). In the first brood (March to May), the cycle is completed in about 72 days as against 60 days in the second brood (June-July). Although, because of bacterial contamination, phenology of the remaining two broods could not be completed, it is possible that the generation build up of the pest becomes quicker during the main flushing period to enable it to cause maximum damage. It is worth noting here that a single female may lay 400 -1000 eggs.

In the field, tea directly under shade tree is attacked more severely primarily because shade trees are the sites for oviposition by the adult moths. In addition to *Dalbergia assamica, Albizzia odoratissima, A. chinensis, and Derris robusta, Indigofera teysmanii* has

Table 6.03. *Phenology of looper, Buzura (Biston) suppressaria Guen*

Period	Incubation period (days)	Duration of different instars (Days) I	II	III	VI	V	VI	Pupa	Mean duration days of life cycle
1st Brood (March-May)	14.5	6.0	5.5	6.0	4.0	4.0	13.0	19.0	72.0
2nd Brood (June-July)	13.0	5.0	3.0	2.5	4.0	4.0	10.5	18.0	60.0

been recorded as preferred sites for oviposition. The newly hatched caterpillars do not feed so much on the foliage of *Indigofera teysmanii* as they do on other shade trees. As caterpillars come down to tea immediately after hatching damage to tea under this particular shade could be very severe.

Sampling of field populations of looper shows that the caterpillars are parasitized by a braconid (*Apanteles taprobanae* Cameron), and the pupae by a diptera (*Sarcophagus* sp). The braconid feeds inside the body of the early stage caterpillar, and on fourth/fifth instar stage it develops into a pupa. Loopers having parasitized cocoons on their bodies were found on 47% of the bushe samples studied. The actual number of cocoons varied between 1 and 7 per bush. In the laboratory, from a single cocoon 22 to 100 parasites emerged to attack the early instar loopers made available to them. The population of these parasites was at its maximum in May. It possibly plays a major role in the natural regulation of looper population.

SAP FEEDERS

A. Tea Helopeltis : Tea helopeltis causes long term damage to bushes by sucking out the sap from productive shoots. One of our experiments shows the loss from this pest could well be in the region of 30,000 kg of made tea from about 135 hectares of tea plantation. Infestation records on two Tocklai and two non-Tocklai clones show (Table 6.04) that because of its succulent leaves TV1 bushes are most preferred hosts for this pest.

Table 6.04. *Relative incidence of tea Helopeltis on some clones under comparable conditions (n 25)*

Clones	Average shoots infested per bush
TV 1	81.71
TV 9	36.13
Deling 13	45.53
Keyhung 1	44.70
S_3A_3	19.59

Once the shoots are damaged, the symptoms develop within 2-3 hours. At the incipient stage, a light brown spot appears at the point of sucking, which gradually develops into an irregular patch. A single late instar nymph is capable of producing about 80 such spots in 24 hours. In one experiment, a single nymphs produced 541 damaging spots in ten days, damaging 17 tender shoots in the process. It is thus possible that only a few *Helopeltis* adults/nymphs could cause the damage of consequence within a short period.

Adults lay eggs on tender stems between first and second leaf, and on the petiole of the first leaf, occasionally on midrib. Eggs are laid in rows of three or four: sometimes more eggs remain embeded in plant tissues. A single female lays about 25 eggs (range 14 to 30), and the life cycle is completed in 15 days in summer against 30 days in winter.

Trials with several new insecticides show that if *Helopeltis* is adequately controlled it invariably leads to a significant increase in the number of productive shoots in the tea bush.

B. Thrips : Thrips are major sap feeders in the Dooars, where following the adoption of longer pruning cycle their numbers have increased considerably. The relative effects of differential pruning on the abundance of thrips were assessed under the following conditions of pruning :

1. Light skiff
2. Leveloff skiff
3. Deep skiff
4. Prune

Abundance of thrips varied seasonally with the degree of pruning. By and large, pruned tea was least affected, and the infestation was maximum on skiffed tea. At the peak level of infestation, i.e. around June-July, there was no significant difference in the overall population of thrips on any form of skiffed tea. Abundance of thrips may well be a function of foliage abundance, though the effect is possibly confounded with intrinsic rate of multiplication of the insects

C. Scale insects : Seasonal population cycles and levels of infestations of *Chrysomphalus ficus, Aonidiella aurantii, Parlatoria proteus, Hemiberlesia latanae, Pinnaspis theae, Fiorinia theae and Aspidiotus destructor* on clones TV1, TV9 and CP1 were evaluated. Although levels of infestations by these scales varied on the clones, in all species, irrespective of clones the population peak was reached in December. This is interesting considering that the seven species of scales are neither synaptic nor sympatric.

Phenological studies show that during April-May the duration of the crucial immature stages *of Parlatoria proteus* is approximately 30 days, and 35 days for that of *Velataspes serrulata*. Since insecticides can easily penetrate

through the soft shells of immature stages, the duration and timing of their appearance are of utmost importance in developing spraying schedules against this pest.

COCKCHAFER

The incidence and degree of attack of cockchafers on two and three year old clonal plants, and two year seedlings, were studied in the Dooars. For each treatment 100 plants were examined. Results (Table 6.05) indicate initially there may not be a significant difference in the intensity of cockchafer attack, but with time, infestation level increases on clonal plants.

Table 6.05. *Extent and intensity of cockchafer damage in the Dooars*

Treatments	Mean no. of grubs/ plant (around collar region)	Average degree of infestation
	Observation on 24.6.77	
2 year clonal plant	0.08	0.15
3 year clonal plant	0.09	0.11
2 year seed plant	0.07	0.15
	Observation on 22.7.77	
2 year clonal plant	0.02	0.37
3 year clonal plant	0.04	0.19
2 year seed plant	0.03	0.10

SHOT HOLE BORER

A survey of the distribution and abundance of shot hole borer shows the involvement of the following three species.

1. *Xyleborus fornicatus* Eichh.
2. *Xyleborus piceus* (Mots)
3. *Xyleborus approximatus* Sch. var.

The habitat and mode of attack of these three species vary, showing in each case, intrinsic characteristics and biological requirements of the species (Table 6.06). *X. fornicatus* attacks thick branches

Table 6.06. *Distribution of three species of Xyleborus in different zones of tea bushes*

Physical condition / Bush zone	Frame	Collar region	Root zone
Waterlogged		*X. piceus*	*X. piceus*
Non-waterlogged	*X. approximatus* *X. fornicatus*	*X. approximatus* *X. fornicatus*	

on the frame, and rarely collar region of non-waterlogged tea. *X. piceus*, on the other hand, attacks the collar region and roots of waterlogged tea, and X. *approximatus* prefers thick partially dead branches and collar region of non waterlogged tea.

On infested bushes, the beetle population may be high in the region of 240—400 beetles per bush. All the three species excavate tunnels within the bushes. In field trials application of four rounds of 0.18% Endosulfan 35% EC significantly stopped the formation of new galleries i.e. infestation spread was contained.

SHADE TREE PESTS

Green aphis : Green aphis, *Megousoparsus dooarsis* Ghosh and Roychoudhury, is a pest of *Indigofera teysmanii*. Freshly emerged nymph moults four times before becoming adult. The duration of life-cycle occupies 6 -9 days in April -May.

Assessments of green aphis populations were made at monthly intervals from the count of aphis on eight randomly selected shoots drawn from 25 plants. The data show that the population starts building up from February, reaching the peak in March, and from April onwards it declines to a low level of abundance (Fig 6.13)

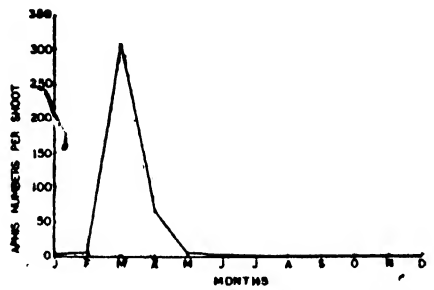


Fig 6.13. Incidence of Green aphis in different months

B. **Survey of shade tree pests :** A preliminary survey of shade tree pests was made in the Dooars. It shows that green caterpillar, *Rhesala moestalis* is prevalent on *Albizzia chinensis* and *A. odoratissima* when they are of 1 year to 4 year old. Plant lice (Psyllids) on *A. chinensis* and *A. procera* in the age of group 1 to 3 years; *Catopsillia crocale* on *Cassia siamea* of 1 to 3 years and the Membracid, *Oxyrachis tarandus* on *A. procera* between 4 and 10 years are common. Shade trees up to 5 years of age are most susceptible to pest attack.

The incidence of pests on different species of shade trees in Assam is shown in Fig 6.14. A scale, *Coccus*

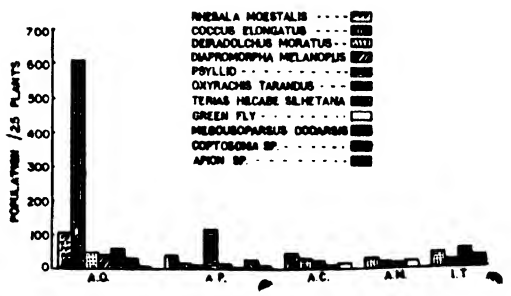


Fig 6.14. Incidence of pests of different species of shade trees

elongatus is on increase on *Albizzia odoratissima*. All these pests are not common at any point of time on a particular shade tree : this suggests a diversity in the infestation by these insects on different species of shade trees. In young (1–4 year old) shade trees (*A. odoratissima A. procera, A. moluccana, A. chinensis and Indigofera teysmanii*), *Coccus elongatus Rhesala moestalis, Megousoparsus dooarsis* and *Deiradoleus moratus* were the main pests.

NEMATODES

A. **Effect of soil heating on root knots :** Soil heating to kill nematodes in nursery soil has been tried. Sieved and pulverised sandy loam soil, having high root knot population, were treated at 60—70°C for 4—5 minutes. As soon as the soil started steaming, it was turned to ensure uniform heating. The treated soil was kept in pots in which tea seedlings were planted. A set of another pots with unheated soil was also planted with tea seedlings (control series). 90 days after the plants were uprooted, the roots were washed clean and examined.

Results (Table 6.07) show that in preheated soil nematodes failed to infest the seedling : indeed population did not survive in the treated soil.

Table 6.07. *Effect of soil heating on root-knot nematode infestation of tea seedlings*

Treatment	Degree of infestation	Number of galls/plant	Percentage of root infested
	(Mean of 12 replications)		
Heated soil	0	0	0
Unheated soil	2.55	26	70

B. **Biology of Paratylenchus** sp. : Tea seedlings, raised in steam sterlised sandy loam soil, were inoculated with 1000 *Paratylenchus* sp. per plant : there were 12 replications of one seedling in each pot. Another set of 12 pots with non-inoculated seedlings was kept as control. A third set of pots, without any plant but only with *Paratylenchus* sp. was kept.

After 90 days, all the plants were uprooted, and their heights and weights were measured. The soil samples from the three sets of pots were also processed for *Paratylenchus* population. Data (Table 6.08)

Table 6.08. *Effect of Paratylenchus on growth of tea seedlings*

Treatments	Average plant height cm	Average plant weight gm	Average Nematode population/100 gm of soil
1 Paratylenchus + plant	22.4	3.95	900
2 Only plant	22.8	4.00	—
3 Only Paratylenchus	—	—	480

show that infestation at the density level tried (1000/plant) failed to cause any significant decline either in plant weight or plant height. It is also interesting that in the presence of seedlings, the population was maintained at a near steady level, whereas in the absence of seedlings it nearly declined to half.

C. **Effects of different soil types with different soil pH on Meloidogyne infestation in tea :** Silty loam and silty clay loam soils, having pH of 4.0, 4.5, 5.0 and 5.5 were kept in pots and planted with tea seedlings. Each seedling was inoculated with 1500 larvae of *Meloidogyne incognita*. 90 days later, the inoculated seedlings were uprooted and their roots were examined for *Meloidogyne* infestation.

Table 6.09. *Effects of different soil types with different soil pH on infestibility of M. incognita on tea. Results based on means of 12 replications*

Soil type	Soil PH	No. of gall per plant	Degree of infestation	No. of egg mass per plant	% roots infested	Average egg output
Silty clay loam	4.0	11.2	2.43	8.4	60	Low
	4.5	12.5	2.62	10.0	60	Moderate
	5.0	23.0	2.44	14.6	60	Moderate
	5.5	8.0	1.31	4.5	30	Low-Moderate
Silty loam	4.0	13.7	1.64	10.4	33	Low
	4.5	12.0	2.33	16.0	60	Moderate
	5.0	19.6	3. 0	19.6	70	Moderate
	5.5	17.25	3. 0	18.2	69	Moderate

In both silty loam and silty clay loam soils, and at all pH ranges, the nematodes multiplied and infested root tissue nearly at the same rate. However, the number of egg masses and egg output at pH 4.0, in both types of soils, were relatively low. Irrespective of the variation in pH, the nematode activity i.e. the number of galls per plant, degree of infestation, egg masses per plant and egg output, were comparatively more in silty loam than in silty clay loam soil.

TOXICOLOGICAL STUDIES WITH NEW PESTICIDES

A. **Growth inhibiting insecticide :** Benzophenylurea (Dimilin 25 W), which is an insecticide cum growth regulator, has been evaluated against two lepidopterous pests i.e. looper (*Buzuria (Biston) suppressaria*) and bunch caterpillar (*Andraca bipunctata walker*). Dilutions used for looper *Buzuria (Biston) suppressaria*) were at 1 part in 250 and in 500 parts of water by volume. The mortality after 96 hours was 62.5 per cent in both the dilutions. In case of bunch caterpillar (*Andraca bipunctata*), the mortality recorded afer 96 hours of treatment at dilutions of 1 in 500 and 1 in 1000 parts was 75% and 50% respectively. The growth rate of surviving caterpillars was slow, and some failed to develop into next instar. Further studies are in progress.

B. **Plant based insecticides :** Three insecticides of Plant origin developed by Regional Research Laboratory, Jorhat, under the code names CP-1, S-2 and S-3 were tested on bunch caterpillar (*Andraca bipunctata*) to study the insecticidal properties of these compounds. Dilutions used were 1 in 250, 1 in 500 and 1 in 1000 parts water. None at the dilutions mentioned gave satisfactory control of the caterpillars. Experiments will be continued using other pests.

Two newly developed, less hazardous, but extremely potent insecticides, Sumicidin and Bioresmethrin were tested against bunch caterpillar (*Andraca bipunctata*) at different dilutions of 1:1000, 1:2000, 1:4000 and 1:8000. Mortality recorded after 24 hours of treatment was nearly 100 per cent at all the dilutions. Further experiments using pests other than bunch caterpillars are in progress.

Experimental acaricide : Preliminary study has been made with four NCL pesticides, derived from Carene containing cyclopropane ring, to find out whether they will have any acaricidal properties at 0.5% and 1% concentrations. All these chemicals when sprayed with acetone solvents, showed strong acaricidal properties.

Bioeffectiveness of Ethion 50 E.C. manufactured with NCL technology was assessed against red spider mite (*Oligonychus coffeae*) at a dilution of 1 in 500 parts water by volume. Mortality rate of the mite after 96 hours of application using this formulation was compared with that of standard Ethion. The results were comparable.

Dicofol manufactured by Hindustan Insecticides Ltd. was tested on red spider mite (*Oligonychus coffeae*). The efficacy of this acaricide was at par with other standard Dicofol formulations.

SCREENING AND EVALUATION OF PESTICIDES

A. **Red spider control :** Six new formulations of Ethion and Ekalux 25 EC were tried against red spider at a standard dilution of 1 part in 200 parts of water by volume. Efficacies of these formulations in controlling the mite varied, although the percentage and composition of active ingredient in all the formulations of Ethion were the same. It is possible that auxillary materials in the formulations affected the overall biotoxicities of these formulations. Ekalux gave about 57% control of adult mites, and performance of the Ethion formulations varied between 47% and 92% in different cases.

A new acaricide, Acrex, was used as palliative against field populations of red spider, along with four new formulations of Tetradifon. They were sprayed at a toxic level of 0.05% and 0.04% : all gave good control of red spider. In a second series, a new formulation of Teepol was added to Acrex and Tetradifon formulations : in both cases performance of the acaricides increased with the adjuvant.

B. **Purple mite control :** Two formulations of Ethion, Cyanotox and Tedion were tried at 1:200 against purple mites in the Dooars. Pre-treatment counts show little variation in the numbers of mites in different plots and a near uniform distribution. Post treatment counts on fourth day and one month after the application of acaricides is shown in table 6.10. All the formulations were nearly equitoxic and the cumulative mortality at the end of four weeks was fairly high.

Table 6.10. *Effect of some acaricides on purple mite*
No. of purple mites per 50 leaves (Mean of 3 replications)

Treatments	Pre-treatment count	After 4 days of treatment	After 1 month of treatment
Asated	162	23	40
Asakel	178	13	43
Asathion	198	15	38
Ethion	165	18	32
Cyanotox	185	38	54
Tedion	162	54	32
Control	177	164	75
Mean C.D.	Not significant	65.34	11.66
CV %	21.48	78.96	15.53

C. **Looper caterpillar control :** Effectiveness of Ekalux EC 25, Elsan 50 EC, Cidial 50 EC and Thionex 35 EC were evaluated against populations of mixed looper instars. Each insecticide was sprayed with a mist blower at a blanket rate of 1.25 liters in 200 liters of water per hectare. In a second series, Dimilin was sprayed at two dilutions i.e. 0.8 kg and 0.6 kg to a hectare. All these insecticides, except Thionex, gave satisfactory control of loopers (Table 6.11), though from this study the differential responses of the caterpillars in various stages of growth could not be sorted out.

Table 6.11. *Comparative efficacy of different insecticides against looper caterpillars one week after application of insecticides*
Date of spraying 27.5.77
Equipment — Mist blower

Treatments	Observations after 1 week	
	Living population of looper per 20 plants	% reduction over control
Elsan 50 EC	15.00	84.4
Cidial 50 EC	21.33	77.9
Dimilin 25 WP	10.67	88.9
Dimilin 25 WP	20.33	78.8
Ekalux 25 EC	9.33	90.3
Thionex 35 EC	82.33	14.7
Control	96.67	-
Least significant difference at P = 0.05	44.48	—

D. **Helopeltis control :** In assessing the effectiveness of Elsan 50 EC, Ekalux EC 25, Nuvacron 40

WSC and Endosulfan 35 EC against tea Helopeltis, the increase in the number of pluckable shoots following the control of the pest was assessed. Each insecticide was sprayed at dilutions of 1 in 200 and 1 in 400 parts of water by volume using an ordinary power sprayer. The increase in the percentage of unaffected shoots, one month after the insecticidal treatment, for each insecticide is shown in (Table 6.12).

Table 6.12. *Increase in productive shoots following control of Helopeltis one month after treatment*

Insecticides	Mean number of unpunctured shoots		
	Pre-treatment	Post-treatment	Percentage of increased shoots over pre-treatment count
Ekalux	59.67	560.00	838
Elsan	55.33	499.33	803
Nuvacron	56.00	457.33	717
Endosulfan	66.67	487.67	631
Control	119.67	489.67	309

It is interesting that in one series, i.e. in non-treated control, production of shoot also increased by 300% : this possibly happened because of drift of the insecticides from treated to non-treated plots which were nearly contiguous.

E. **Termite control :** Endocel 35 EC, Cidial 50 EC, X factor and Dursban 20 EC at a blanket rate of 10 liters per hectare were evaluated against *Microcerotermes*. The insecticides were applied to bush frame following removal of earthen runs. All these treatments kept the bushes free of termite damage for about a year, though actual reduction level of infestation was in the region of 60% (Table 6.13). It is possible that at this level of population termite damage is minimal.

Table 6.13. *Comparative efficacy of different insecticides against termites*

Treatments	Observation after 1 year	
	Average degree of infestation per plant	% reduction over control
Endocel 35 EC	0.22	60.71
Cidial 50 EC	0.22	60.71
X-factor	0.26	53.57
Dursban 20 EC	0.20	64.28
Control	0.56	—
Least significant difference at P= 0.05	0.26	—

F. **Cockchafers control :** Palliative treatments against cockchafers in young tea were given using Ekalux EC 25, Elsan 50 EC, X-factor, Thimet 10G, Furadan 3G and Endosulfan 35 EC. All insecticides, except Thimet and Furadan, were applied at a dilution of 1 part in 500 parts of water by volume. Thimet and Furadan were used at 10 gm per bush. Assessments were made three months after the application of the insecticides, to find out the degree of attack. Results (Table 6.14) show that even after three months all these insecticides significantly reduced the degree of cockchafer attack and the number of bushes attacked were also low.

Table 6.14. *Effect of chemicals on cockchafers*

Treatments	% bushes attacked (Mean of 3 replications)	Degree of attack (Mean of 3 replications)
Ekalux EC 25	8.33	0.08
Elsan 50 EC	16.68	0.20
X' factor	14.67	0.18
Thimet 10 G	16.67	0.20
Furadan 3 G	10.02	0.14
Endosulfan 35 EC	11.67	0.18
Control	25.00	0.33
Mean C. D.	10.72	0.15
C.V. %	40.91	47.37

G. **Nematode Control :** Prophylactic control trials against parasitic nematodes in tea nursery using DBCP, Thimet 10 G, Temik 10 G and Mocap 10 G were carried out. DBCP was applied by an injector gun, while the granular nematocides were broadcast over the area and forked into the soil. Year after the treatment the seedlings growing in the plots were uprooted and final observations made. The data are presented in Table 6.15.

DBCP was most effective because the degree of infestation and number of galls per plant were significantly less in DBCP treated plots than in other treatments. The percentage of transplantable plant, and of eelworm free seedlings, and the green weight per plant were significantly more in DBCP treated plots than in other treatments.

The percentage of transplantable plants were significantly more in Thimet treated plots than in plots treated by Temik and Mocap.

Table 6.15. *Efficacies of different nematocides against root-knots*

Treatments	Degree of infestation per plant	Number of galls/ plant	Percentage of transplantable plants	Percentage of eelworm free seedlings	Green wt. per plant (g)
	Mean of 4 replications				
DBCP @ 40 l/ha	0.35	2.83	91.47	77.05	69.63
Temik 10 G @ 90 kg/ha	1.37	9.46	60.30	32.25	36.81
Thimet 10 G @ 20 kg/ha	1.28	9.33	74.38	36.27	42.24
Mocap 10 G @ 100 kg/ha	1.08	9.03	72.07	39.48	44.30
Control	1.33	10.82	67.12	31.23	37.37
Least significant difference at P= 0.05	0.28	3.60	11.96	9.45	13.14
C. V. %	17.23	28.54	10.66	14.22	18.51

The degree of infestation was significantly more in Temik treated plots than in plots treated with Mocap and Thimet.

There was no significant difference in the efficacies of Temik, Thimet and Mocap in so far as number of galls per plant, green weight per plant and percentage of eelworm free seedling were considered.

The final levels of eelworm populations in the trials are shown in table 6.16.

Table 6.16. *Nematode population levels following nematicidal treatments*

Treatments	Population/100g soil
DBCP	15
Temik	25
Thimet	30
Mocap	40
Control	55
Mean C. D.	31.20
C. V. %	61.36

In respect of eelworm population, only DBCP proved to be superior to control.

In a palliative control trial against root knot nematodes in tea seedlings in sleeves, using Temik 10 G @ 1 g and 0.5 g per plant, Mocap 10 G @ 0.5 g per plant and Furadan 3 G @ 1 g per plant, more transplantable plants were obtained from blocks treated with Temik 10 G @ 0.5 g per plant. Further trials are in progress.

STUDIES ON PESTICIDE RESIDUE TOLERANCE

Wet and Dry weather samples of manufactured and sun-dried tea treated with Cythion 50 EC. (Malathion) and Ekalux EC 25 have been processed for residue analysis. Results are awaited.

QUALITY CONTROL OF PESTICIDES

Quality control studies on different formulations of 27 acaricides and 7 insecticides received from a number of tea estates were made and reported.

PESTICIDE CERTIFICATION

14 Certificates of approval were issued to various formulations of plant protection chemicals. 23 Certificates were revalidated after bioassay studies. Agreements were made for formal testing of 31 formulations of various pesticides.

ADVISORY SERVICES

Soil samples and pest damaged materials were examined and reports were communicated to the estates. Out of 2300 soil samples about 11.5% were found unsuitable because of high eelworm population.

GENERAL

An extension of Entomological laboratory has been set up in the Dooars to deal with regional pest problems in the Dooars, Terai and Darjeeling.

High degree of black rot control was achieved by applying fungicides to infected bushes in the year of pruning.

Power sprayer can be used for effective control of red rust. with 1:100 dilution of copper fungicides.

Nickel chloride is practically ineffective in controlling blister blight during the spells of heavy rains; it is also less efficacious even when used in combination with a standard copper fungicide.

The Charcoal stump rot fungus, Ustulina zonata *has a high cellulolysis adequacy index, which indicates its ability to survive irrespective of the nitrogen status of the soil: it is incapable of utilising nitrite as a source of nitrogen.* U. zonata *is capable of withstanding high grade interfungal interaction.*

Armillaria mellea, *the root split disease, was reported from some more estates in Darjeeling.*

Application of copper oxychloride, metham sodium, endosulfan, simazine, diuron, and nemagon to soil in the laboratory showed a spurt of growth of micro organisms having high saprophytic ability. Hyphal lysis and abnormal swellings were also recorded in some. Highly tolerant forms have also been encountered.

Application of commercial biofertilizers in a look-see trial has indicated positive response in certain clones but not in other clones.

Fungicides

During this year fifteen formulations were tested for their efficacy in control of red rust, black rot and blister blight. Of these, four fungicides were claimed to possess better sticking and wash-resisting properties. Three of these were tested against red rust and black rot. The fourth, "Olcocop", was not used being an oil based formulation, it requires dispersal with a diluent oil, thus creating the problem of tainting and phytotoxicity.

Red rust

Two series of experiments were conducted. One was mainly aimed at evaluating more tenacious fungicides under wet conditions prevailing during the actively disseminating phase in the life history of the organism. Hand operated sprayers were used for spraying these fungicides. The second series was utilized to study the influence of low concentration of fungicides using power sprayers.

This year it rained almost everyday during the sporulating period of the alga. The development of spore bearing sporangial structures was rather sporadic and real heavy incidence of the disease was rare. However, the climatic conditions were ideal for the evaluation of fungicides which are claimed by their formulators to be rainfast. Hence three such fungicides *viz.* Fycol, Flowable Copper and Copper Oxychloride with aluminium hydroxide, were tested along with few other fungicides in two experiments carried out in two different gradens.

The first experiment was laid out in an unshaded young tea area at Tocklai, planted in 1970-71 at 120 × 90 × 60 cm spacing. The following treatments were randomized in four replications, each replication consisting of five plots of 36 bushes i.e. 2 rows of 18 bushes each; 2 rows of guard lines were left in between the plots, to eliminate effects of spray drift.

Treatments

1. Copper oxychloride with Aluminium hydroxide 0.25%
2. Blitox 0.25%
3. Flowable copper 0.25%
4. Fycol 0.25%
5. Control

In this Blitox was considered as standard. 4 applications were made; starting from 20.4.77, the first two at fortnightly interval, and subsequent ones at monthly intervals, the last round was on 29.6.77. Hand operated Bakpak sprayers were used. The degree of overall control was assessed by bush to bush examination of the experimental area and the results are given in Table 7.01.

Table 7.01. *Degree of red rust infection per bush and percentage of the disease control (mean of 144 bushes).*

	Treatments	Rate	Degree of infection per bush	% reduction over control
1.	Copper oxychloride + Aluminium hydroxide	1:400	0.45	59.82
2.	Blitox	,,	0.33	70.54
3.	Flowable copper	,,	0.42	62.50
4.	Fycol	,,	0.57	49.11
5.	Unsprayed control	,,	1.12	
	CD at P = 0.05		0.29	
	CV %		32.21	

The degree of infection per bush in sprayed plots is significantly lower than in control plots but there is no significant difference amongst the fungicides tested. However, when interpreted into percentage Blitox gave 70.54% reduction in disease, taking control as no reduction (100% attack); while flowable copper 62.54%, copper oxychloride + aluminium hydroxide 59.82% and Fycol 49.11%. Earlier, various dilutions of Fycol were noticed to cause burning of the leaves when bright sunshine followed spraying. No such observation was possible this year as rainy or cloudy weather prevailed after each spraying.

The second experiment was conducted in a commercial garden in Titabar circle, where heavy infection of the disease was recorded in 1969-hedge-planted (120 ×

90 cm) and not-too-well-shaded area. Fytolan was used in place of Blitox, as standard fungicide. Another fungicide, Kishan, a copper oxychloride formulation, was also included in this trial, making altogether six treatments, including the unsprayed control in this experiment, which was laid out in 4 blocks, consisting of 6 plots of 27 bushes each. All the treatments were imposed with hand operated Bakpak sprayers using a 1 in 400 concentration of the fungicide concerned. There were 4 rounds of application, as in the preceding experiment, the first application was done on 6.5.77 and the final one on 15.7.77. The results are given in table 7.02.

Table 7.02. *Degree of Red rust infection per bush and percentage of the disease control (mean of 108 bushes)*

	Treatments	Rates	Mean incidence per bush	% reduction over control
1.	Flowable copper	1:400	0.25	88.7
2.	Kishan	1:400	0.38	82.8
3.	Fytolan (standard)	1:400	0.42	81.0
4.	Copper oxychloride + Aluminium hydroxide	1:400	0.44	80.1
5.	Fycol	1:400	0.51	76.9
6.	Control (unsprayed)		2.21	
	CD at p = 0.05		0.44	
	CV %		41.98	

All the fungicides tested significantly controlled the disease, the degree of control achieved in the second experiment was however, high because the incidence was higher when compared to the first trial.

Different concentrations with Power Sprayers: This series of trial was intended to find out an effective dilution with a power sprayer for applying a recommended fungicide. Two experiments were conducted.

One experiment was carried out in a 6 year old, unshaded, staggered double hedge (120×90×60 cm.) planted tea, showing low degree infection. Plots were of 78 bushes (39×2 rows) and each treatment was replicated 6 times with 2 rows of guard lines between the plots. Fungicides were applied in 2 rounds, on 2.6.77 and 7.7.77 when the disease build up was noticed.

Treatments

1. Fytolan 1 : 100
2. ,, 1 : 200
3. ,, 1 : 300
4. ,, 1 : 400

The results are given in Table 7.03

Fytolan at 1:100 and 1:200 gave better control than at 1:300 and 1:400.

In the other experiment, the same treatments were repeated in an area on one estate in Titabar circle where the degree of infection was much higher. The area was hedge planted (120 × 60 cm.) in 1969 and was unshaded

Table 7.03. *Degree of infection of red rust per bush with percentage control achieved (mean of 120)*

	Treatment	Rate	Mean degree of infection per bush	% reduction over control
1.	Fytolan	1:100	0.53	70.56
2.	,,	1:200	0.56	68.89
3.	,,	1:300	0.89	50.56
4.	,,	1:400	0.94	47.78
5.	Control		1.80	
	CD at p = 0.05		0.22	
	CV %		18.97	

and the bushes were in very poor health. The treatments were applied in 4 standard rounds between 6.5.77 and 15.7.77. Plots were row of 25 bushes with 4 replications. The results are given in table 7.04.

Table 7.04. *Mean degree of incidence of red rust per bush as affected by application of a standard fungicide (Fytolan) in different concentrations when applied with a power sprayer (mean of 100 bushes)*

Fungicide	Concentrations	Mean degree of incidence per bush	% reduction over control
Fytolan	1:100	0.17	92.2
,,	1:200	0.67	69.3
,,	1:300	0.65	70.2
,,	1:400	0.95	56.4
Control (unsprayed)		2.18	
CD at p = 0.05		0.45	
CV %		31.37	

Fytolan at 1 in 100 was significantly superior to all the concentrations tried and here the degree of incidence of the disease was higher than what it was in the preceding experiment. It would thus appear that 1:100 dilution of a standard copper fungicide, sprayed with a power sprayer, can effectively control red rust. This has the advantage of low chemical use and quick coverage as compared to standard application by hand operated sprayers.

Branch canker

Two chemotherapeutants are being studied for their ability to protect the pruning cut from infection by *Poria* in the plains. They were applied in March 1975 immediately after pruning, on the pruning cuts. Observations till date suggest that Coal Tar (Indopaste) is superior to the other product Pancil. T.

An I. C. I. coded product PP 395 was applied to heavy pruned tea in January 1974 in a garden in Darjeeling to test its protective action against Thorny stem blight *Tunstallia aculeata* Syn. *Aglaospora*. As the pathogen is a slow invading wound parasite, the observations will continue.

Black rot

During the season two experiments were laid out to screen different formulations against black rot in skiffed and pruned tea. Another experiment was initia-

ted to assess the efficacy of a standard formulation when applied with a power sprayer in different dilutions as compared with the standard dilution with hand operated sprayer.

Screening

On a garden in the Nahorkatia circle an area carrying youngish mature light leaf Assam tea, planted in 1959-60 at a spacing of 150 × 75 cm, was found to suffer severe infection by black rot when examined in the preceding season. The area was light pruned during the 1976 cold weather. Here, all the three fungicides supposed to be tenacious, with Kishan and a standard fungicide Fytolan were tried. There were altogether 6 treatments including the unsprayed control and each treatment was replicated 4 times, with 20 bushes in each plot.

Two applications were made with a hand operated Bakpak sprayer, at fortnightly interval, the first round on 26.4.77 and the second on 10.5.77. The plots were separated by guard lines which received the spray of the adjoining plot but were not observed for the disease development. Bush to bush observation was made on the degree of incidence in the 0 –4 scale, as was done in the past and the results are presented in Table 7.05.

Table 7.05. *Degree of black rot infection per bush and percentage of disease control (mean of 80)*

Treatments	Rate	Degree of infection	% infection with control as 100	% reduction over control
Fytolan	1:400	0.30	16.1	83.9
Copper oxychloride + Aluminium hydroxide	1:400	0.25	13.4	86.6
Kishan	1:400	0.31	16.7	83.3
Flowable copper	1:400	0.46	24.7	75.3
Fycol	1:400	0.30	16.1	83.9
Control		1.86	100.00	
CD at p = 0.05		0.38		
CV %		43.59		

Excellent control has been achieved by all the fungicides tested. Of the more tenacious fungicides, only copper oxychloride with aluminium hydroxide, had a slight edge over the standard fungicide Fytolan, while Flowable copper affected a slightly lower degree of control. This trend is, however, not maintained as would be seen from the following experiment.

The experiment was repeated in another area in a 1953-54 planted light leaf Assam jat tea in the same estate. The tea was well shaded and identically spaced with one difference that this was light skiffed. The spraying was done in 25.4.77 and 9.5.77.

The results are presented in Table 7.06.

In this experiment also all the fungicides gave significant reduction of the disease. A pertinent observation is that the degree of control obtained in the first experiment in the "pruned" year, was definitely superior to

Table 7.06. *Degree of black rot infection per bush and percentage of disease control (mean of 80)*

Treatments	Rate	Degree of infection	% infection with control as 100	% reduction over control
Fytolan	1:400	0.50	32.0	68.0
Copper oxychloride with Aluminium hydroxide	1:400	0.54	34.6	65.4
Kishan	1:400	0.58	37.2	62.8
Flowable copper	1:400	0.60	38.5	61.5
Fycol	1:400	0.56	35.9	64.1
Control		1.56	100.0	
CD at p = 0.05		0.41		
CV %		38.11		

that in the second experiment. This indicates that better control of black rot can be achieved by applying fungicides in the pruned year.

Experiments with different dilution

The trial was meant to find out a suitable concentration for a power sprayer in applying a standard fungicide. For this, the degree of control as achieved by applying the recommended fungicide with a hand sprayer was taken as the standard and its performance was compared with that of the different concentrations of fungicides applied with power sprayers. Altogether five treatments including the untreated control were randomised over 480 bush plots with three replicates. Fungicides were applied in two rounds and the applications were made under estate supervision. Observation on the degree of incidence of the disease was made by us on 60 bushes of each plot and the results are presented in the following table (Table 7.07).

Table 7.07. *Degree of black rot infection per bush with percentage control achieved (mean of 180)*

Treatments	Rate	Sprayer	Degree of infection	% infection with control as 100	% reduction over control
Blitox	1:100	power	0.75	51.0	49.0
"	1:200	"	0.92	62.6	37.4
"	1:400	"	0.98	66.7	33.3
"	1:400	Hand-sprayer	0.78	53.1	46.9
Control			1.47		
CD at p = 0.05			0.32		
CV %			17.16		

It is evident that the performance of the fungicide (Blitox) at 1 in 100 concentration applied with power sprayer is similar to that of standard application rate of 1 in 400 using hand sprayers. It is also superior to other concentrations tried with the power sprayer.

The standard application gave less than 50% control. This can be attributed to the fact that in this skiffed area the management could apply the second round only after a lapse of six weeks because of incessant rain. The efficacy of the therapeutant was, therefore, adversely affected in this trial.

Blister blight.

In 1977 season two experiments were conducted in Darjeeling for the control of blister blight. Of these, one (experiment 1) was continuation of an experiment laid out in 1976 and the other (experiment 2) was to test the efficacy of Nickel chloride at different rates along with some other fungicides.

Experiment 1

In this experiment the treatments (for details please refer to Ann. Rep. 1976-77, p. 49) were applied as soon as the disease build up was noticed in early July'77. Spraying was continued at weekly and bi-weekly intervals, till the end of the blister season in September 1977. The experiment aims at estimating the effect of the treatments on yield through a complete pruning cycle.

The effect of treatments on the incidence of blister blight as recorded on the date of application of the 6th round is shown in Table 7.08.

Table 7.08. *Effect of treatments on control of blister blight*

Treatments	Rate/ ha	Interval in days	Rounds	No. of blisters per 100 shoots	% reduction
Blitox	625 g	7	6	20.33	80.15
Fungikill	,,	7	,, ,,	29.67	71.47
Tamraghol	,,	7	,, ,,	28.67	72.43
Copper oxy-chloride	,,	7	,, ,,	23.00	77.88
Calixin 1: Mowlith 2	200 ml	14	3	19.33	52.57
Calixin 1: Mowlith 3	,,	14	,, ,,	54.00	48.08
Calixin 1: Mowlith 4	,,	14	,, ,,	70.00	32.69
MBC	625 g	14	,, ,,	103.00	0.96
Hard plucking (weekly throughout observation)				103.67	0.32
Control				104.00	
CD at p=0.05				24.56	
CV %				21.43	

The performances of the fungicides were almost similar to that in 1976. Hard plucking has been practised as one treatment but it did not cause any reduction of the disease.

The yield records will be analysed only on completion of the pruning cycle.

Experiment 2

This was a fungicide evaluation trial using hand sprayers. Blitox, Kishan and Captan were applied at 1 in 800 parts of water. Quantities of Nickel chloride and Calixin sprayed per hectare are given in Table 7.09. There were 11 treatments including an unsprayed control series. These were applied to plots of 40 bushes randomized in 3 replicates. Spraying was done immediately after a plucking round at seven day intervals. Only in case of Calixin, the application was at 14 day interval. The number of blisters in 100 shoots collected at random every week. The final observation made one week after the application of the last round, is given in Table 7.09.

Table 7.09. *Effect of different fungicides on the control of blister blight*

Fungicides	Rate/ha	Spray interval in days	No. of rounds	Blister per 100 shoots	% reduction over control
Calixin 1 : Mowlith 4	200 ml	14	2	100.67	40.78
Kishan	1:800	7	4	28.00	83.53
Captan	1:800	7	4	102.67	39.61
Blitox	1:800	7	4	30.00	32.35
Nickel chloride	625 g	7	4	60.33	64.51
Nickel chloride	450 g	7	4	76.00	55.29
Nickel chloride	350 g	7	4	87.67	48.43
Nickel chloride	250 g	7	4	94.33	44.51
Nickel chloride + Blitox	310 g + 310 g	7	4	66.00	61.18
Dithane M 45	1:800	7	4	83.00	51.18
Control				170.00	
CD at p 0.05				32.75	
CV %				23.53	

These results show that Calixin, Captan and Dithane M45 have little effect in controlling the blister. Nickel chloride brought down the disease incidence by about 64% when applied at 625 g/ha, but not at lower dosages i.e. at 450, 350 and 250 g/ha. Combined with Blitox in equal proportions, half the Nickel chloride (310 g/ha) was as good. Copper fungicides; Blitox and Kishan @ 1:800 effectively controlled blister blight.

A very interesting phenomenon was noticed in the expt. When sprayed during rains, copper formulations have better rainfastness and residual protectant properties than nickel based fungicides. It may also be mentioned that nickel formulations have been observed to induce massive scorch if sprayed during hot weather.

In this experiment five treatments including control were :

1. Nickel chloride + copper formulation @ 310 g/ha each/round
2. Copper formulation @ 625 g/ha/round
3. Nickel chloride @ 450 g/ha/round
4. Nickel chloride @ 6 25 g/ha/ro und

Incessant rainfall was encountered during the last three rounds of spray (10th, 17th & 31st August '77). Observation continued on three occasions till 14.9.77 after the last round of spray.

Under the N.E. India's conditions nickel chloride alone or in combination with Blitox appears to be less efficacious than copper formulations like Kishan or Blitox during rainy spells.

Agrimycin 100 in blister control

As a preliminary study, some severely blister infested areas were sprayed with Agrimycin and copper in october/November in Upper Assam. No difference were observable in blister infection at this stage. Further experiments are being planned for 1978 in Assam as well as in Darjeeling.

Root rots

Six experiments on soil fumigation for the control of root rots laid out on member estates in 1974-76 are still under observation. No mortality has been reported from the treated plots both replanted areas and fumigated living stands of mature tea which showed infestation before treatment.

Investigation into the nature of control of the primary root rots by fumigation was made by studying the soil microflora from the treated and untreated area. In the treated soil there were a high populations of saprophytic organisms like *Trichoderma viride*, *Aspergillus flavus*, *A. terreus*, *A. fumigatus*, *A. niger*, *A. versicolor*, *Mucor racimosus*, *Cunninghamella echinulata*, *Gliocladium fimbriatum*, *Chaetomium globosum*, four species of *Fusarium*, one sp. of *Thielaviopsis* and four species of *Penicillium*. The saprophytic forms have a high sporulating and great cellulose decomposing (utilising) ability. They detoxify the toxic metabolites produced by the pathogens and inhibit the growth of pathogenic fungi in soil (Tocklai Conf. 1977, p. 54-56).

Ustulina zonata has a high cellulolysis adequacy index (CAI) which is indicative of the fungus's ability to exist irrespective of the nitrogen status of the soil. *U. zonata* is incapable of utilising nitrite as a source of nitrogen as is the case in many of the soil fungi.

U. zonata is capable of withstanding high grade interfungal interaction 'C' (because of the regression value of 0.93 in the laboratory studies made utilising Wastie's cellophane agar plate technique). Co-existing soil fungi like *Trichoderma viride* strains (?) and *Aspergillus niger* induced *Ustulina* colonies to produce fluffy mycelial growth, indicating synergism?

Armillaria mellea was reported from some estates in Darjeeling. Soil fumigation experiments will be laid out during 1978-79.

Rosellinia arcuata (black root rot) was reported from one more estate in Upper Assam and the control measures have been suggested (Soil fumigation).

Soil microbiology

Constantly larger number of fungal and bacterial species are present in the rhizosphere soil as compared to non-rhizosphere soils. Ecologically all the forms come under Winogradsky's AUTOCTHNOUS types.

Soil microbes show differential behaviour in their tolerence to agrochemicals at different times and periods. Organisms like *Nitrosomonas* which converts ammonia to nitrate, *Nitrobacter* which converts nitrite to nitrate, *Azotobacter* which is said to have the ability to fix non-symbiotic atmospheric nitrogen and denitrifying bacteria which convert nitrite to nitrous or free nitrogen and liberate it into the atmosphere, have been isolated and these were found to exist in soils whether treated or untreated with agrochemicals. Nevertheless, a temporary reduction in fungal and bacterial numbers was observed following the application of agrochemicals.

Laboratory studies using soil extract amended with copper oxychloride, metham sodium, endosulfan, simazine, diuron and nemagon showed *Fusarium*, *Trichoderma*, *Aspergillus* and *Mucor*, as dominent species, while in the untreated series, several other forms were found. The selectivity thus revealed, supports the earlier findings that application of these chemicals promotes a spurt of growth of the micro-organisms having high saprophytic ability.

The dominant forms of fungi listed above are sensitive to chemicals in as much as they reveal morphological changes like hyphal-lysis and abnormal swellings of the mycelium on application of these chemicals. Interestingly one ascomycetous fungus (yet to be identified) had tolerated a very high concentration (1:400) of metham sodium.

Ability of certain soil fungi to grow in presence of agricultural chemicals like simazine, diuron, copper oxychloride and endosulfan indicate their ability in lowering the concentration of these chemicals in soil by degradation or utilisation in their system. This aspect requires further investigation. The microbiological investigations were conducted by a research fellow.

Violet root rot (Sphaerostilbe repens B. & Br.)

Autecological studies on the Violet root rot causing organism confirmed that the pathogen could spread in the soil adhering diseased roots as distinct rhizomorphs and is not affected by microbial antagonism or excess moisture. It has a very high biotic potential as it produces large number of spores. Ability to grow in the interzone of bark and the root tissue is indicative of its saprophytic nature

In laboratory experiments, it produced chlamydospores and utilised the filter paper as source of carbon.

Bio-fertilisers

Past work on the studies of non-symbiotic nitrogen fixation by *Azotobacter* and *Beijerinckria* in acid soils did not reveal any significant nitrogen addition to the normal tea soils (1976-77 Ann. Rep. p. 50).

During 1977-78 a look-see trial was conducted using three biofertilisers on some stocks available in a Botany plot at Tocklai. The stocks in the experiments were 397, 449, 450 and 378. Biofertilisers applied to the

soil and their rates of application tried were Aries Agro-AZO (@ $\frac{1}{4}$ pkt. for 20 bushes, Bactogin (Bactogin lab. Jabalpur) (@ one pkt. for 20 bushes, and Theabacter meal (Tea Chem., Calcutta) (@ 3 kg for 20 bushes. Each control plot had 20 bushes that were not treated.

Application of biofertilisers was done on 7th July 1977 and the yield records were taken between mid August and end September 1977.

Table 7.10. *The yield of green leaf mid August to end September over 6 weeks taking control as 100 following application of biofertilizer*

Treatment	STOCKS			
	397	449	450	378
Aries Agro AZO	97.8	113.2	118.6	114.1
Bactogin	92.7	141.4	94.7	100.0
Theabacter Meal	102.6	110.1	—	—
Control :	100.0	100.0	100.0	100.0

These studies will continue

The yield responses were positive on the stocks treated with Theabacter meal. Aries Agro AZO had positive response on stocks 449, 450 and 378 while 397 showed a decline, Bactogin produced gain in yield in stock 449 maintained the level of control in 378 while depressed the yield in 397 and 450.

Though no definite conclusion on the benefits of addition of biofertilisers, is possible at this stage, stock 449 showed consistant increase in yield with all the biofertilisers investigated (Table 7.10). This appears to be due to factors other than nitrogen fixation. It may be recalled that in 1976-77 experiments were in pot culture studies using test tube inoculum while in 1977-78 it was in the field using commercial bio-fertilizers.

Pigment profiles for different skiffing and pruning operations have been characterised.

The stem of a tea shoot has been found to be poor in respect of its tea making potentials.

One of the factors for quality deterioration during rains appears to be high concentration of chlorophyll and chlorogenic acids in the shoot.

Some loss in enzyme activity of tea leaf was observed on storage and withering of the leaf. Soluble sugars and chlorophyll contents also undergo changes during manufacture of green leaf to black tea.

Proving trials for factory floor fermentation tests were conducted in commercial tea factories.

PIGMENT PROFILE STUDIES

These studies were extended with the object of differentiating flushes, skiffing/pruning operations and fermentation times.

(i) Flush quality

Pigment profiles of the made teas from unpruned and deep skiffed bushes of Clone TV 18 showed that rains quality predominated almost throughout the plucking season of 1977. It may be noted in this connection that only for a very brief period during the last week of May, there was a slight rise in quality which was but an admixture of rains and second flush quality, as indicated by the pigment profiles. The opinions of tea tasters in general, corroborated the pigment profile analyses (Table 8·01).

Table 8.01. *Taster's evaluation of C.T.C. teas from unpruned and deep skiffed bushes of TV 18*

Date of manufacture	Nature of skiffing	Taster's remarks	Valuation Rs/kg
17.5.77	Deep skiff	Some useful character, bright	8.00
20.5.77	Unprune	Although green much better quality. First flush character	12.00
24.5.77	Deep skiff	Touch of 1st flush character	9.00
31.5.77	Deep skiff	A combination of 1st and 2nd flush character	12.00
3.6.77	Unprune	Post 2nd flush character	10.00
7.6.77	Deep skiff	Very raw and green on the palate	8.00

(ii) Quality of unpruned and deep skiffed teas

Pigment profiles of C.T.C. teas from unpruned and deep skiffed bushes of TV18 revealed that the peak heights of the profiles for unpruned tea was lower than those of the deep skiffed tea during the whole season. This shows that deep skiffing produces better quality teas than unpruned. The theaflavin (TF) and thearubigin (TR) contents of made teas also support this observation (Table 8·02).

Table 8.02. *TF and TR of C. T. C. teas from unpruned and deep skiffed bushes of TV 18*

Date of manufacture	Nature of pruning	% TF	%TR	TF/TR
17.5.77	Deep skiff	1.53	19.18	0.08
20.5.77	Unprune	1.47	17.40	0.07
31.5.77	Deep skiff	1.90	17.84	0.10
3.6.77	Unprune	1.50	18.16	0.08
14.6.77	Deep skiff	1.28	19.69	0.06
17.6.77	Unprune	1.10	18.71	0.06
26.7.77	Deep skiff	1.39	13.97	0.09
29.7.77	Unprune	1.37	14.09	0.09
2.8.77	Deep skiff	1.44	14.40	0.10
5.8.77	Unprune	1.09	17.18	0.06

The TF content is always found to be higher in the leaf from deep skiffed bushes than from unpruned. Besides, the former gives a better distribution ratio of TF and TR.

(iii) Fermentation time

Leaves from unpruned and deep-skiffed bushes of TV 18 were fermented for 1 h, 1 h 20 m 1 h 40 m, 2h and the C.T.C. teas were subjected to pigment profile analysis. According to pigment profile, it was observed that fermentation periods of 1 h 20 m to 1 h 40 m produced the best quality teas in floor fermentation, both from unpruned and deep skiffed bushes. These findings were also confirmed by the tea tasters (Table 8.03).

Table 8.03. *Taster's valuation for C.T.C. teas fermented for different lengths of time*

Date of manufacture	Type of pruning	Fermentation time	Valuation Rs/kg
10.6.77	Unprune	1 h	6.50
		1 h 20 m	6.00
		1 h 40 m	7.00
		2 h	6.00
28.6.77	Deep skiff	1 h	6.00
		1 h 20 m	6.00
		1 h 40 m	8.00
		2 h	7.00
1.7.77	Unprune	1 h	7.50
		1 h 20 m	8.50
		1 h 40 m	7.50
		2 h	7.00
5.7.77	Deep skiff	1 h	6.00
		1 h 20 m	7.00
		1 h 40 m	7.00
		2 h	6.50

CHEMICAL BASIS OF FLUSH QUALITY

In our earlier work on the chemical basis of quality of tea, it was observed that enzyme activity and total oxygen uptake of fresh tea shoots were correlated positively and amino acids and chlorophyll contents were correlated negatively with the quality of tea. Characterisation of flush characters by pigment profile studies

had shown that, in addition to various other chemical constituents, distribution of chlorophyll and chlorogenic acids plays an important role in determining flush characters. The second flush teas possess less of these chemicals than the rains teas. Their concentration is lower in the autumnal than in the rains teas, although it is still higher than in the second flush.

(i) Chemical composition of shoot components

The above observations were based on the chemical analyses of whole shoots. A tea shoot is far from being chemically homogeneous, since the occurrence and distribution of the chemicals differ between the components of a shoot. It is already known that the polyphenol and caffeine contents decrease from the tender to the mature parts of a tea shoot. An experiment was therefore planned to examine the individual parts of a tea shoot in respect of some of the chemical components.

Leaf samples were collected from Clones TV7 (DS) and TV 18 (DS) and shoots were separated into component parts and analysed for moisture, dry matter, enzyme activity, total oxygen uptake, chlorophyll and amino acids by using analytical methods reported earlier. For estimation of the chlorogenic acids, a thin layer chromatography (TLC) method was developed in the laboratory. Methanolic hydrochloric acid extract of the dried green leaf was subjected to two-dimentional TLC on cellulose plates with butanol: acetic acid: water: : 4: 1: 5 followed by 5% aqueous acetic acid. Four spots of chlorogenic acids located under ultra violet light were eluted with 50% ethanol and the optical density (O.D.) was measured at 324 nm. The concentration of the chlorogenic acids was calculated on the basis of the extinction co-efficient (19,200) of 3-caffeoyl quinic acid. Table 8.04 gives the average values over the whole season for moisture, dry matter, enzyme activity, total oxygen uptake, chlorophyll, chlorogenic acids and amino acids for different parts of tea shoots.

Table 8.04 *Average values (on dry wt.) over the season of chemical constituents of individual parts of tea shoots from Clones TV 7 and TV 18*

Source	Shoot component	Seasonal average for						
		% Moisture	% Dry matter	Enzyme activity μlO_2 /mg/h	Total oxygen uptake μlO_2/mg/2h	% Chlorophyll a + b	% Chlorogenic acids	% Amino acids
TV 7 DS	Bud	74.77	25.23	11.66	9.03	0.17	0.49	1.99
	1st leaf	72.63	27.37	11.66	10.26	0.24	0.59	0.74
	2nd leaf	73.05	26.95	12.85	10.45	0.37	0.55	1.11
	Stem	82.55	17.45	16.35	7.26	0.19	0.72	3.79
	Weighted mean for the whole shoot	75.75	24.25	13.13	9.25	0.24	0.59	1.91
TV 18 DS	Bud	75.45	24.55	12.59	9.07	0.26	0.49	2.41
	1st leaf	73.59	26.41	13.37	8.78	0.40	0.66	1.37
	2nd leaf	74.07	25.93	12.17	8.80	0.55	0.61	1.77
	Stem	84.21	15.79	17.37	6.93	0.23	0.90	4.86
	Weighted mean for the whole shoot	76.83	23.17	13.88	8.16	0.36	0.67	2.69

It is evident from the table that the stem contains about 10 per cent more moisture than the other components of the shoot. The moisture content decreases in the order: stem, bud, second leaf and first leaf. The dry matter contents follow a reverse order being minimum in the stem and maximum in the first leaf.

The lowest oxygen uptake is observed in the stem although it has the maximum enzyme activity. This is attributable to its low substrate (polyphenol) concentration.

The stem contains the highest proportions of amino acids and chlorogenic acids. The concentration of chlorophyll in the stem, however, is low and similar to that of the bud. The second leaf being in an advance stage of development, contains the maximum concentration of chlorophyll.

Based on our earlier observations it is clear from the weighted averages of the two clones that TV7 is a better clone than TV 18, its oxygen uptake being higher and chlorophyll, chlorogenic acid and amino acid contents lower than that of TV 18.

(ii) Chemical composition of shoot components during different flushes

Since the chemical composition of a shoot does not remain the same throughout the plucking season, those of the components of a shoot are also expected to vary in the course of the growing season, as Table 8.05 shows.

There are certain variations in the chemical composition of the shoot components during the different flushes. In clone TV7, enzyme activity increased with the progress of the season, while no such distinct trend was observable in clone TV 18. Total oxygen uptake of the bud and the leaves was the least during autumn but the stem portion of TV7 showed an opposite trend. The lowest concentration of chlorophyll and chlorogenic acids was observed during the second flush and the highest during the rains.

Table 8.05. *Flushwise average values (on dry wt.) of chemical constituents of different parts of shoots from clones TV 7 and TV 18*

Source	Shoot components	Flush	Flush average for: Enzyme activity μlO_2/mg/h	Total oxygen uptake μlO_2/mg/2h	% Chlorophyll a + b	% Chlorogenic acids
TV 7 DS	Bud	2nd	10.5	8.95	0.16	0.47
		Rains	10.8	9.32	0.21	0.50
		Autumn	16.2	8.25	0.17	0.49
	1st leaf	2nd	10.98	10.83	0.23	0.57
		Rains	11.22	10.27	0.26	0.60
		Autumn	14.10	9.35	0.24	0.58
	2nd leaf	2nd	11.70	10.77	0.32	0.51
		Rains	12.38	10.61	0.40	0.56
		Autumn	16.10	9.50	0.33	0.55
	Stem	2nd	15.77	6.70	0.19	0.68
		Rains	16.57	7.30	0.20	0.74
		Autumn	16.50	7.80	0.19	0.71
TV 18 DS	Bud	2nd	12.28	8.38	0.23	0.47
		Rains	12.58	8.38	0.29	0.50
		Autumn	12.81	6.99	0.26	0.49
	1st leaf	2nd	13.04	9.78	0.36	0.67
		Rains	13.19	8.85	0.45	0.68
		Autumn	14.17	7.62	0.43	0.67
	2nd leaf	2nd	11.67	9.90	0.47	0.61
		Rains	12.42	8.90	0.59	0.62
		Autumn	12.05	7.40	0.54	0.61
	Stem	2nd	18.06	7.74	0.19	0.81
		Rains	17.76	6.89	0.25	0.94
		Autumn	15.67	6.46	0.22	0.89

Weighted averages for different flushes (Table 8.06) of the two clones show that there is a trend of chlorophyll and chlorogenic acids concentrations being higher in Autumn than in the Second flush and maximum during the Rains flush. This observation is in support of our earlier findings from the pigment profile study (Ann. Rep. 1973-74) for flush characterisation of tea.

Table 8.06. *Flushwise weighted mean of the chemical components for the whole shoot from TV 7 and TV 18*

Source	Flush	Weighted mean for the whole shoot: Enzyme activity μlO_2/mg/h	Total oxygen uptake μlO_2/mg/2h	% Chlorophyll	% Chlorogenic acids
TV 7	Second	12.24	9.31	0.22	0.56
	Rains	12.74	9.37	0.27	0.60
	Autumn	12.72	8.72	0.23	0.58
TV 18	Second	13.76	8.95	0.31	0.64
	Rains	13.97	8.25	0.39	0.68
	Autumn	13.67	7.12	0.36	0.66

There is hardly any difference in the total oxygen uptake (substrate concentration) during the Second and Rains flushes, whereas during the Autumn, the oxygen uptake goes down indicating lowering of the substrate concentration towards the later part of the season. The enzyme activity, however, remained same in all the three flushes of both the clones. Because of relatively high enzyme activity the autumnal teas will be brighter and brisker than the rains teas, but due to low substrate concentration (total oxygen uptake) at this time of the year, these teas will comparatively lack in body. Presence of high concentration of chlorophyll and chlorogenic acids appears to be one of the factors for deterioration of rains quality.

EFFECT OF MANURING ON TEA QUALITY

Potash

Application of potash appeared to enhance the condensation of amino acids into protein (Ann. Rep. 1976-77) which adversely affects the quality of tea. Analysis of tea leaf from three different levels of potash manuring (0, 45 and 180 kg per hectare) showed increased levels of protein with concomittant decrease in the amino acid content (Table 8·07).

Table 8.07. *Effect of potash manuring on the protein and amino acid levels of tea leaf*

Potash level kg/ha	% Amino acids	% Protein
0	2.18	13.51
45	2.02	14.27
180	1.92	14.93

CHANGES OF SOLUBLE SUGARS AND CHLOROPHYLL DURING BLACK TEA MANUFACTURE

Certain loss of water soluble sugars and chlorophyll was observed during the withering process (Table 8.08)

Table 8.08. *Water soluble sugars and chlorophyll contents at different stages of manufacture*
(Figures are average of TV1, TV15 & TV18)

Components	Fresh leaf	Withered leaf	Fermented leaf: C.T.C.	Fermented leaf: Orthodox	Made tea: C.T.C.	Made tea: Orthodox
% Water soluble sugars	1.540	1.249	1.289	1.315	1.323	1.373
% Chlorophyll	0.273	0.234	0.131	0.148	0.106	0.114

The soluble sugar level increases during fermentation primarily due to degradation of the polysaccharides into simple sugars. Drying of the fermented leaf does not have any significant effect on the soluble sugar content.

The chlorophyll of green leaf undergoes degradation into black coloured phaeophytin and brownish phaeophorbide during the successive stages of processing from withering to drying. The extent of degradation of chlorophyll is higher in C.T.C. than in Orthodox process (Table 8·08) resulting in lower concentration of chlorophyll in the C.T.C. teas. The details of this study will be reported later.

EFFECT OF STORAGE AND WITHERING ON ENZYME ACTIVITY AND TOTAL OXYGEN UPTAKE OF TEA LEAF

There is always a time gap between the plucking of the tea leaf and its processing. During this gap, the leaf continues to respire at the cost of its sugar content and as a result there is certain loss in the solid matter of the leaf. The enzyme systems are also active during this period and it is likely that some other chemical changes also occur. An experiment was therefore planned to examine the effect of storage and withering on the enzyme activity and total oxygen uptake of tea leaf.

Leaf was collected from TV1 in ice box and carried to the laboratory immediately for analysis. Another lot of leaf sample was stored in plucking baskets and analysed after 2 and 3 hours. A third lot was spread and allowed to wither naturally for 18 hours and then analysed. The experiment was repeated on twelve occasions spread over the season. The average values are presented in Table 8.09.

Table 8.09. *The effect of storage and withering on the enzyme activity and total oxygen uptake of tea leaf from TV 1*

Treatment	Enzyme activity μlO_2 /mg/hr	Total oxygen uptake μlO_2 /mg/2h
Ice box	16.4	11.2
2 hrs in basket	14.8	11.2
3 hrs in basket	14.5	11.5
18 hrs wither	12.8	11.5

Data in the table indicate that there is certain loss of enzyme activity of the fresh leaf during its storage in plucking baskets for 2 and 3 hours as well as in withering. There is however no change in the total oxygen uptake of the leaf under these conditions. This shows that inspite of some degradation of the oxidase enzyme during storage and withering, there is no effect on oxidation of the polyphenols, the quantity of which does not undergo any change.

FACTORY FLOOR FERMENTATION TEST

A factory floor fermentation test based on the measurement of optical density (O.D.) of TF was reported last year. The test was modified to suit the conditions of large scale manufacture and was conducted during the year in Cinnamara, Hunwal and Sycotta tea factories with success. The test has been found useful in different manufacturing methods, like C.T.C., Orthodox and Dual manufacture.

In the modified test, 5 g of the fermenting leaf is infused with 100 ml of boiling water for 1 minute during which period it is constantly stirred or shaken. After filtration through cotton wool, 5 ml of the infusion is treated as described earlier (Ann. Rep. 1976-77).

For C.T.C. manufacture, the highest O.D. of the extract corresponds to the optimum fermentation of the tion time should be extended by 10 minutes after obtaining the highest O.D. of the extract.

It is advisable to conduct the test at intervals of 5 minutes when the critical period of fermentation is approached.

The made tea samples corresponding to each test conducted with the fermenting leaf were evaluated biochemically and also sent to Calcutta and Tocklai Tea Tasters for valuations. Results of the tests for different methods of manufacture are presented in Table 8.10.

Table 8.10. *O.D. of TF, biochemical evaluation and Tasters' valuations of made teas corresponding to fermentation tests*

Ferm. Time	O.D. at 460 nm	% TF	% TR	Valuations Calcutta	Rs/kg Tocklai
C.T.C. Manufacture					
Floor Fermentation					
1 h	0.250	1.40	16.08	17.25	6.00
1 h 10 m	0.260	1.58	16.09	18.00	7.50
1 h 20 m	0.240	1.24	16.18	17.65	6.00
1 h 30 m	0.220	1.14	16.94	17.80	6.50
1 h 40 m	0.210	1.08	17.16	17.50	7.00
1 h 50 m	0.205	1.01	17.58	17.25	6.00
2 h	0.205	1.06	17.80	17.25	6.00
Trough Fermentation					
1 h	0.350	1.71	13.84	14.75	6.50
1 h 10 m	0.355	1.78	13.20	14.75	7.00
1 h 20 m	0.360	1.76	14.54	15.00	6.00
1 h 30 m	0.375	1.89	14.40	15.00	8.50
1 h 40 m	0.305	1.73	16.02	15.00	7.00
1 h 50 m	0.300	1.62	16.66	14.75	6.50
Orthodox— Floor Fermentation					
2 h 15 m	0.090	0.88	6.57	14.80	7.50
2 h 25 m	0.105	1.15	7.20	14.50	6.00
2 h 35 m	0.105	1.10	7.84	15.00	8.00
2 h 45 m	0.090	0.92	8.68	14.00	6.00
Dual Manufacture					
Trough Fermentation					
First Fine					
1 h 50 m	0. 12	0.86	7.20	17.50	6.00
2 h	0.135	0.99	8.19	18.25	7.00
2 h 10 m	0.150	1.13	8.61	19.00	8.00
2 h 20 m	0.140	1.08	9.60	18.50	9.00
Second Fine					
1 h 50 m	0.180	1.01	8.40	15.50	7.50
2 h	0.180	1.00	8.75	16.00	7.00
2 h 10 m	0.185	1.08	9.39	15.50	7.50
2 h 20 m	0.175	0.92	10.52	17.00	8.00
C.T.C.					
1 h 45 m	0.315	1.62	14.12	13.80	6.00
1 h 55 m	0.320	1.70	15.20	13.90	6.50
2 h 5 m	0.340	1.84	17.74	14.00	7.00
2 h 15 m	0.260	1.53	18.68	12.50	7.00

The results indicate that for C.T.C. manufacture the highest O.D. for TF corresponds to an ideal distribution of TF and TR in the resulting teas thus indicating that the optimum fermentation is achieved at the particular point of time. However, for orthodox manufacture, the formation of TR has also to be considered.

are formed without causing any appreciable loss in TF content. Alternatively, the fermentation time in orthodox manufacture should be extended by 10 minutes after obtaining the maximum for TF. This and the earlier test developed by Dr. K. L. Bajaj have been found useful at Tocklai in the selection of vegetative clones. Leaflet containing both these tests will be available in due course.

Diversification of products

A joint project in collaboration with "Instant Tea Project" is being taken up from February, 1978 to study the chemistry of Instant tea in relation to quality and manufacture. Three staff members of the Instant Tea Project are being trained in the department in laboratory techniques for the estimation of some of the chemical components of tea. A number of Instant tea samples prepared in the Instant Tea pilot factory have been analysed for biochemical evaluation.

Advisory services

A number of detergents and water samples received from different Tea Estates were tested and advice was given on their suitability for use in tea factories.

Kaybee and N-Foss Moisture meters sent by different Tea Companies were standardised and calibrated.

Tea samples received from Estates and Advisory departments of Dooars were analysed for biochemical evaluation.

Valuation of a jat tea was improved by mixing small quantities of clonal tea of better quality. A good jat tea had similar effect on clones of lesser quality. More fines could be extracted with advantage from a mixer of clones than from a mixer of jats in dual manufacture. The ratio of volume of tea to surface area of the tea chest increases as the size of the tea chest diminishes and the absorption of moisture by the packed tea was observed to increase in proportion to the ratio.

BLENDING OF JAT AND CLONE

A blending experiment was carried out to assess the cup quality by mixing of clonal tea with jat tea in different proportion. For this experiment three popular Tocklai released clones TV1, TV9, TV18 and Betjan jat were selected. The method of manufacture was C.T.C. and the made tea was mixed under the following proportions and the made tea blend was tasted by two leading blenders.

Table 9.01. *Proportion of clonal and jat (Betjan) in tea blends and Valuations in Rs/kg*

Blender A

Clone in blend		Blend with clone TV 1	TV 9	TV 18
0	(Betjan)	13.00	13.00	13.00
5%		14.00	13.00	13.00
10%		14.00	13.00	12.00
15%		14.00	13.00	14.00
20%		14.00	13.00	12.00
100%	(Clone)	15.00	12.00	11.00

Blender B

Clone in blend		Blend with clone TV 1	TV 9	TV 18
0	(Betjan)	14.00	14.00	14.00
5%		15.00	13.50	14.00
10%		15.00	13.50	14.00
15%		15.00	15.00	13.50
20%		14.50	14.00	13.50
100%	(Clone)	15.00	14.00	13.00

From the Table 9.01 it appears that presence of even a small quantity of TV1 can give a perceptible boost to the liquor characters but larger proportion of TV1 had adverse effect of the bulk tea. Similarly, mixing with good jat tea improved the valuation of clonal tea of esser quality.

Dual manufacture with different extractions in jat and clones :

In continuation of the previous investigations on dual manufacture with different extractions (Annl. Rep. 1974-75, pp 48) further observations were made on the effect of cup characters of C.T.C. teas made with mixed jat and mixed clones separately, after extractions of 10%, 20% and 30% fines in each case.

Tea Tasters from Calcutta, Gauhati and Tocklai constituted the panels for assessment of the liquor characters. The valuations given by the tasters are given in Table 9.02 to illustrate the effect of extraction of fines.

Table 9.02. *Valuation (Rs/kg) of mixed clones and mixed jats of tea in dual manufacture*

Fines extracted	Mixed jat Ortho-dox	C.T.C.	Average	Mixed clone Ortho-dox	C.T.C.	Average
			Taster A			
10%	13.0	9.0	9.4	14.5	10.5	10.9
20%	12.0	8.5	9.0	14.7	10.4	10.8
30%	11.2	7.0	8.3	13.7	8.5	10.1
			Taster B			
10%	12.0	8.0	8.4	13.0	10.0	10.3
20%	11.3	7.0	7.6	13.3	9.9	10.2
30%	9.5	6.0	7.1	12.0	8.5	9.6
			Taster C			
10%	10.0	7.3	7.5	11.0	8.5	8.8
20%	9.3	7.0	7.3	11.3	8.4	8.7
30%	7.0	5.6	5.6	10.0	6.5	7.6

Average = Weighted average

Table 9.02 shows that for mixed clones extraction of fines can be higher than for mixed jats. In the case of clones, 20% extraction did not have any adverse effect on liquors (of mixed clones) whereas it depressed the value of mixed jats.

PACKAGING & STORAGE

Material for lining of tea chests

During the year some lining materials were tested for their suitability.

Lining of regenerated cellulose film under the brand name 'Trayophane' was tested against standard aluminium foil lining in small 5 kg plywood tea chests. Teas stored in these chests were tested for (a) moisture content (b) chemical changes and (c) odour and taint and were evaluated by Tasters. Results of the tests for moisture content are presented in Table 9.03 and for biochemical evaluation of TF and TR in Table 9.04.

Table 9.03. *Per cent of moisture content of tea stored in 5 kg chests lined with Trayophane and Aluminium foil*

Details of samples	Period of storage (months) commencing from 13th May, 1977						
	0	1	2	3	4	5	6
Orthodox tea							
Tissue paper plus Trayophane	3.0	5.71	7.30	9.11	10.75	11.63	11.26
Trayophane only	3.0	6.12	7.20	8.66	10.18	10.64	11.18
Trayophane plus Tissue paper	3.0	5.45	7.59	8.32	9.86	10.61	10.98
Aluminium foil	3.0	5.73	6.67	8.15	9.35	10.10	10.49
C.T.C. tea							
Tissue paper plus Trayophane	4.7	7.03	8.01	9.38	10.64	11.85	12.02
Trayophane only	4.7	7.77	8.18	9.40	11.38	11.90	11.90
Trayophane plus Tissue paper	4.7	6.96	7.73	8.90	10.53	10.43	11.20
Aluminium foil	4.7	6.68	7.60	8.41	11.52	11.30	10.09

Table 9.04. *Changes in TF and TR during storage of teas for 1, 3 and 6 months in differently lined chests*

Treatments	Length of storage	Ortho-dox %TF	(GFOP) % TF	C.T.C. % TF	(PF) % TR
Tissue paper plus Trayophane	1 month	0.53	9.76	0.71	17.31
Trayophane only		0.67	11.18	0.93	14.71
Trayophane plus Tissue paper		0.56	10.39	0.85	15.62
Aluminium foil		0.62	9.91	0.81	13.84
Tissue paper plus Trayophane	3 months	0.37	6.88	1.03	17.25
Trayophane only		0.39	7.23	1.06	17.28
Trayophane plus Tissue paper		0.37	6.74	1.03	16.82
Aluminium foil		0.44	6.95	1.00	16.35
Tissue paper plus Trayophane	6 months	0.50	8.88	0.52	13.99
Trayophane only		0.55	8.86	0.51	13.51
Trayophane plus Tissue paper		0.56	9.53	0.68	15.11
Aluminium foil		0.52	8.40	0.53	13.72

Teas stored in these small 5 kg chests absorbed 9 to 11 per cent moisture after 3 months, irrespective of the type of lining used, showing that small chests are unlikely to give any reliable information in such experiments.

Teas stored in small tea chests with 'Trayophane' lining showed noticeable fall of liquor characters and off-flavour contamination as the period of storage increased.

In another set of experiments using non-commercial size tea chests another regenerated cellulose film lining under the brand name 'Kesophane' was compared against standard aluminium lining. Table 9.05 shows the percentages of moisture in tea after 1, 3 and 6 months of storage and Table 9.06 gives the TF and TR values of teas stored for 1 and 6 months.

Table 9.05. *Per cent moisture content of tea stored in 36 cm × 36 cm × 40 cm tea chests lined with 'Kesophane' and conventional aluminium foil linings*

Treatments	Each chest containing 20 kg made tea	Period of storage			
Orthodox tea		0	1	3	6
Kesophane lining		3.4	8.23	8.21	8.37
Standard aluminium foil lining		3.4	7.93	7.75	8.14
C.T.C. tea					
Kesophane lining		3.1	6.18	7.99	8.19
Standard aluminium foil lining		3.1	6.16	6.88	7.16

Table 9.06. *Changes in TF and TR of teas during storage*

Treatments	Period of storage	Ortho-dox %TF	(TGFOP) % TR	C.T.C % TF	(PF) % TR
Kesophane lining	1 months	0.72	8.12	1.77	15.09
Aluminium foil lining		0.71	8.78	1.77	15.19
Kesophane lining	6 months	0.64	9.99	1.45	16.34
Aluminium foil lining		0.65	10.10	1.43	16.69

Tables 9.05 and 9.06 show that the size of tea chest has important bearing on the moisture gain and is borne out by the surface area of lining as well as the length of the edge which will reduce considerably with the increase in tea chest size.

Biochemical evaluations for both the experiments were done by the Biochemistry Department.

Table 9.07. *Quality assessment of tea from different agro-management Tea techniques*

Title of Experiment	No. of samples manufac-tured	Remarks/Results
1. Management Practices and Biochemical Experiment	436	Not conclusive
2. Residue and tainting trial	44	One product tainted
3. Zinc trial	80	Not significant
4. Nitrogen Vs. Clone	285	Not significant
5. Quality Testing Trial	480	Not significant
6. Estate Clone	128	4 clones gave significantly higher valuation in respect of quality and strength in C.T.C.
7. Assessment of clones	369	9 clones gave encouraging results.
8. Withering	120	Experiment is not complete and being continued.

GREEN TEA

As a part of the product diversification measure, studies on green tea manufacture have been initiated at Nagrakata. Although the factory was not fully equiped with miniature machinery, some trials on green tea manufacture were conducted with the existing tea machinery. More intensive study will be carried out in the commercial gardens.

Evaluation of commercial products

Detergent : Of the few commercial products tried, Rajnol SP was an effective detergent for washing fermenting room floors and processing machinery in tea factories. This detergent sample received, had a pH of 6.8 and found suitable for use.

The following detergents which are generally used by the industry for cleaning fermenting floor and green leaf processing machines were tested again, as received from different tea estates. These detergents were found to have the following pH values.

Name of Detergent	pH Value
Teepol (liquid form)	9.9
Safai (powdered form)	12.5
Saffal (powdered form)	12.5
Safo (powdered form)	13.0
Idet (liquid form)	10.0
Safaa (powdered form)	10.4

The permissible limit that a detergent should have is between pH of 6.5 and 7.0.

Conveyor belting

Conveyor belting from Messrs C.R. Wallace & Co. (P) Ltd., Calcutta, was found suitable for conveying processed green leaf without any deleterious effect on made tea. However, physical strength and durability of the conveyor belt has not been tested.

Advisory works

(a) Tasting Sessions : 42 group tea tasting sessions were held in different areas of N.E. India for the benefit of the planters. These sessions were arranged by the Area Scientific Committees.

The Tea Tasters visited 90 factories on manufacturing problems of the respective estates.

(b) Seminars: Nine Engineering & Manufacturing Seminars held in N.E. India were attended by the Tea Tasters.

(c) Tasting : Number of samples tasted during the year at Tocklai

Tocklai samples	5912
Outside clonal samples	7748
Outside experimental samples	8347
	22007

Number of samples tasted during the year at Nagrakata

Clonal samples	6253
Experimental samples	1800
Estates samples	7543
	15596

The 45 cm prototype Continuous Tea Roller installed at Meleng T.E. continued to give very satisfactory results. The 2nd and the 3rd fines and coarse from this machine, when sorted, gave similar percentages of different primary grades as the conventional rollers give. The valuations of the sorted grades from C.T.R. teas were generally higher than the valuations of the corresponding conventional grades. The 87 cm prototype Continuous Tea Roller has also shown remarkable improvement.

Work was continued on the development of the Withered Leaf Preconditioner, manual plucking aid and a method for seperation of stalks from made tea.

By some modifications of the machining specifications of C.T.C. rollers a 17% increase in the output was found to be possible without any effect on the grade percentages and valuations.

CONTINUOUS GREEN LEAF PROCESSING MACHINES

(a) Continuous Tea Roller

(i) 45 cm Prototype : The 45 cm prototype Continuous Tea Roller was installed at Meleng T. E. in the beginning of the season and manufacturing trials against conventional orthodox manufacture were carried out throughout the year. After some initial troubles which were sorted out the machine started working satisfactorily. Comparative samples from this machine and from conventional roller were tasted by Tocklai Tasters as well as by a broker house and the monthly average valuations given by them are shown in Table 10.01 and Table 10.02.

Table 10.01. *Monthly average valuations given by a Broker House on 45 cm C.T.R. and Conventional teas. Rs/kg*

Month	No. of trials	1st fine		2nd fine		3rd fine		Coarse		C.T.C.	
		CTR	Conv.	CTR	Conv.	CTR	Conv.	CTR	Conv.	CTR	Conv.
April	1	21.50	23.00	21.00	20.00	17.00	19.00	20.00	18.50	19.00	17.00
May	12	21.45	22.18	22.60	21.70	19.00	18.90	17.50	16.33	18.15	17.99
June	16	22.02	22.63	22.73	22.93	21.40	21.54	18.10	18.25	19.33	19.22
July	8	24.24	23.50	21.50	20.62	19.43	19.50	15.78	16.10	–	–

Table 10.02. *Monthly average valuations given by a Tocklai Taster on 45 cm C.T.R. and Conventional teas. Rs/kg*

Month	No. of trials	1st fine		2nd fine		3rd fine		Coarse		C.T.C.	
		CTR	Conv.	CTR	Conv.	CTR	Conv.	CTR	Conv.	CTR	Conv.
April	1	9.75	9.33	8.50	9.50	8.50	8.00	6.50	6.00	7.90	8.10
May	8	9.65	9.35	8.81	8.77	8.12	7.93	6.75	7.16	8.71	8.12
June	15	13.00	12.93	13.20	13.12	12.82	12.93	11.83	11.70	10.64	11.00
July	8	13.75	12.94	14.00	13.56	14.00	13.21	12.78	12.64	–	–

From the table it can be seen that the average valuations of the C.T.R. teas compare well with the valuations of the conventional orthodox teas and except in case of the 1st fine the valuations of C.T.R. teas are generally better than the conventional orthodox teas.

At the instance of the Engineering Sub-Committee the 45 cm prototype Continuous Tea Roller was tried out for a month for the 2nd and 3rd roll after the 1st roll in conventional rollers. The comparative fines and coarse obtained from the Continuous Tea Roller and conventional roller were graded and the comparative grades were tasted by Calcutta, Gauhati and Tocklai Tasters. The average percentages of different primary grades and their average valuations given by different Tasters are shown in Table 10.03. The last row of figures showing the valuations for overall primary grades are calculated by taking the percentage weights of the grades into account for each day's manufacture.

Table 10.03. *Average primary grade percentages and valuations of 45 cm C.T.R. and conventional teas. Rs/kg*

Grades	Percentages		Valuations in Rs/kg given by –					
			Calcutta Taster		Gauhati Taster		Tocklai Taster A	
	CTR	Conv.	CTR	Conv.	CTR	Conv.	CTR	Conv.
$TGFOP_1$	12.60	12.48	18.73	18.16	18.95	18.90	16.04	16.95
TGFOP	10.07	11.41	16.59	17.00	18.36	17.60	15.52	16.19
GBOP	14.28	14.44	18.70	17.96	16.60	15.99	15.33	14.31
FBOP	16.86	16.58	18.72	18.12	16.62	16.51	14.95	14.66
BOPF	4.29	4.80	15.12	14.84	14.61	14.20	14.95	13.48
Over-all Primary grades	58.10	59.71	17.97	17.35	17.29	16.78	15.38	15.19

The last row of figures in the table show that when the 45 cm Continuous Tea Roller is used for the 2nd and the 3rd roll, the overall weighted average valuations of Continuous Tea Roller graded teas are higher than the corresponding valuations of the conventional rollers graded teas. Although the total percentage of primary grades appears to be sightly lower in case of the C.T.R., this is offset by the higher valuation received. It has also been remarked by different tasters that in general the Continuous Tea Roller samples had more chunky tips and a better cup quality.

Before granting a licence for commercial scale manufacture of this machine permission has been granted to each of M/s Steelsworth Ltd. of Tinsukia and M/s Trade & Industry of Tezpur to manufacture two prototypes. These commercial prototypes are expected to be ready by early next season.

(ii) 37 cm Prototype : The 37 cm prototype Continuous Tea Roller was also installed at Meleng T.E. in tandem with the 45 cm machine and was tried out for both dual and 100% orthodox manufacture. Remarkable improvement in its performance was observed after some modifications were made to the rotor and its battens towards the end of the season. However, some further improvement is necessary to bring its performance upto the level of the 45 cm prototype. Comparative samples from this 37 cm prototype and conventional roller were tasted by Tocklai Tasters as well as by a broker house and the monthly average valuations given by them are shown in Table 10.04 and Table 10.05.

Table 10.04. *Monthly average valuations given by a Broker House on 37 cm C.T.R. and conventional teas. Rs/kg*

Month	No. of trials	1st fine		2nd Fine		3rd Fine		Coarse		C.T.C.	
		CTR	Conv.	CTR	Conv.	CTR	Conv.	CTR	Conv.	CTR	Conv.
June	9	20.08	21.31	22.60	25.20	22.25	21.12	17.87	18.50	17.19	17.14
July	3	21.00	20.00	19.25	18.75	19.33	20.16	16.33	16.16		

Table 10.05. *Monthly average valuations given by a Tocklai Taster on 37 cm C.T.R. and conventional teas. Rs/kg*

Month	No. of trials	1st fine		2nd fine		3rd fine		Coarse		C.T.C.	
		CTR	Conv.	CTR	Conv.	CTR	Conv.	CTR	Conv.	CTR	Conv.
June	5	12.97	13.37	13.20	12.60	12.50	11.75	10.12	10.50	11.56	11.53
July	3	14.00	14.50	13.50	13.16	14.16	14.50	14.83	14.50		
Oct.	10	15.66	16.08	14.60	15.80	15.20	15.20	12.00	12.66	—	—
Nov.	13	16.44	15.92	—		—		-		11.50	11.70

These results show that the performance of this machine has considerably improved and now it needs only a little more improvement to become fully satisfactory.

(b) Withered Leaf Preconditioner

The Withered Leaf Preconditioner was modified to make the gap between the rollers adjustable and was fitted with a new set of wooden rollers. This was then installed at Meleng T.E. and was tried out for orthodox manufacture. Withered leaf conditined in this machine was rolled in a conventional orthodox roller and was compared with normal conventional orthodox roller teas of Meleng T.E. The comparative valuations of these teas given by a broker house and the Tocklai Tasters are shown in Table 10.06.

Table 10.06. *Comparative monthly average valuations of teas made with and without Withered Leaf Preconditioner Rs/kg (1st fines only)*

Months	No. of trials	Broker House		Tocklai Taster	
		Pre-conditioner + Roller	Roller only	Pre-conditioner + Roller	Roller only
July	7	24.50	22.93	13.50	13.93
August	5	25.66	25.33	15.20	16.00
October	7	—	--	15.43	15.57

These trials showed that various adjustments were necessary in the machine to get the expected results. As these adjustments were being done simultaneously the machine could be tried out only on a limited number of occasions. From the valuations it is not possible to draw any conclusion about its advantage, but it was often observed that the show of tips in preconditioned leaf was better than in conventional orthodox teas. Hence to prove the efficacy of this machine, particularly in respect of tips it is proposed to use brass rollers in place of wooden rollers. An order has already been placed for the supply of the brass rollers.

(c) Barbora Leaf Conditioner

Commercial production of the Barbora Leaf Conditioner Mark II has been started. Several machines conforming to Tocklai's new specifications have already been supplied to different tea estates and they are working very satisfactorily.

(d) Cutter Attachment for B.L.C. and Rotorvane

The manufacture of the modified Cutter Attachment from stainless steel has been started by the Licensees. Two units have already been supplied to Leesh River T.E. and Chabua T.E. Report on the performance of these new units are expected during the early next season.

CONTINUOUS FERMENTING MACHINE

The commercial production of the Continuous Fermenting machine has been started by M/s Tea-Ma Consortium. One unit, supplied to Cinnamara T.E., is being installed there. Another unit has been exported to Mauritius. The other licensees M/s Steelsworth Ltd. have not yet started its commercial production.

CONTINUOUS TRAY TEA DRIER

Following reports that the Continuous Tray Tea Drier manufactured by M/s Wesman Engineering Co. under TRA's licence, installed at Khongea T.E. was giving some troubles, the drier was thoroughly checked. It was found that the troubles were due to poor workmanship and some inaccuracies, and not to the basic design.

PLUCKING AID

Work on the development of a manually carried non-selective plucking aid has been started and for the purpose of motorising it, assessment of its power requirement is being made.

SEPARATION OF STALKS

Work to find an effective method of seperating stalks from tea is continuing. So far no new method is hit upon, but mechanical limitation of the motion of a sieve, as given to it manually by expert hands, showed some promise. Further work is being taken up in this direction.

IMPROVEMENT OF CTC ROLLERS' OUTPUT

To increase the output of 8 T.P.I.C.T.C. Rollers the following new machining specifications were tried out:

Angle of chasing groove	= 45°
Depth of chasing groove	= 0.096"
No. of helical grooves	= 40
Depth of helical groove	= 0.084"
Angle of milling	= 70°

Manufacturing trials were conducted with a pair of C.T.C. rollers with these new machining specifications against a pair of normal 8 T.P.I., 50 helical groove rollers. In both the cases three C.T.C. cuts of equal severity were applied after rotorvaning. The comparative percentages of different grades and their average valuations alongwith the percentage increase in the capacity of the modified pair of C.T.C. rollers are shown in Table 10.07. It can be seen from this table that on an average a 17% increase in the capacity was obtained from the rollers with modified machining specifications, while the grade percentages and their average valuations were not affected.

Table 10.07. *Trial of C.T.C. Rollers with modified machining specifications*

Grade percentages, valuations in Rs/kg given by Tocklai Taster and % increase in capacity with modification C.T.C. Rollers.

Date	Grade percentages								Valuations Rs/Kg		% increase in capacity with-modified CTC
	Broken		Fannings		Dust		Residue				
	Modified	Normal	Modified	Normal	Modified	Normal	Modified	Normal	Modified	Normal	
25.5.77	42.29	39.63	52.07	52.12	5.07	6.84	0.57	1.41	7.00	6.00	17.5
21.6.77	39.32	39.56	44.82	46.15	13.72	11.54	2.13	2.74	8.00	8.00	15.0
25.6.77	36.38	31.04	51.67	57.14	10.53	10.71	1.11	1.10	9.00	8.00	15.5
2.7.77	29.29	30.78	53.53	55.78	15.91	12.73	1.26	0.70	7.00	8.00	17.0
9.7.77	26.91	24.55	56.66	57.26	15.64	16.99	0.79	1.20	9.50	9.00	15.5
14.7.77	30.85	22.76	52.34	58.53	15.62	17.48	1.18	1.22	7.50	8.50	18.0
16.7.77	31.82	29.63	55.44	54.68	11.27	14.81	1.47	0.87	6.00	6.50	16.5
23.7.77	24.88	23.73	55.13	54.22	19.57	21.44	0.41	0.60	7.00	6.50	17.0
11.8.77	31.27	25.24	54.46	61.33	13.40	12.78	0.86	0.64	6.50	7.00	19.0

GENERAL

During the year the Research Engineer attended seven meetings and seminars held by the Scientific Committees of different areas and visited eleven Tea factories in connection with various problems besides his frequent visit to Meleng T.E. in connection with the trials of the Continuous Tea Roller and Withered Leaf Preconditoner.

Dr. M.G. Hampton, Director of AFP Consultants, U.K. who visited Tocklai from 12th to 20th March as a tea processing expert through the British Council was taken round different factories in Upper Assam and Jorhat area by the Research Engineer to acquaint him with the problems for his study. Mr. B.N.S. Rao, Assistant Research Engineer designate also accompanied him.

The results obtained from the crop and rainfall data for the Southern part of Chalsa sub-district of Dooars suggest that annual yield of tea can be increased by about 39 per cent over the actual yield recorded, if rainfall deficiency is made up by irrigation during the dry cold weather period and adequate measures are taken to drain out excess rain water during the heavy monsoons.

The investigation of the survey data on field management and environmental factors affecting the yield of tea in Darjeeling shows that there is scope to increase the total yield of Darjeeling by extension, using higher plant population per unit area both for extensions and replantation and infilling the vacancies.

The higher yield/ha of T.R.A. member estates as compared to non-member estates in Darjeeling suggests that member estates are utilising the results of research to a large extent. The yield per hectare of tea above seven years old reveals that requirement of and response to nitrogen varies with aspect, elevation, angle of the slope of the section and shade status. It has also been noticed that quantity of nitrogen/ha does not appear to have been applied correctly under various environmental and management conditions. Higher the elevation, the longer pruning cycle gives higher yield.

A large number of experiments on various projects of the station were statistically planned, designed and the method of analysis determined. Computations of the data obtained from these experiments were carried out on the Unit Record Machines installed at Tocklai and on the Electronic Computer.

CROP-WEATHER STUDIES

The study on crop and rainfall data for the Chalsa and Northern part of Nagrakata sub-districts were carried out during the period. The object and method of study were the same as reported earlier in the Annual Scientific Report, T.R.A.

Scrutiny of rainfall and yield data representing the soil climatic conditions of Chalsa sub-district revealed wide variations within the sub-district and it was noticed that this sub-district could be divided broadly into two parts, *viz.*, Chalsa South and Chalsa North, on the basis of rainfall distribution, soil type and level of annual yield. The results obtained for the southern part of Chalsa sub-district are presented below.

Chalsa Sub-district (Southern Part*)

This part has different rainfall distribution and yield level than that of Northern part of the sub-district. The soil type is also different than the other part.

Equation (1) derived from the set of data under study revealed the critical periods and quantity of rain which affected the annual yield of tea in this part of the sub-district, and also their relative nature of relationship with the annual yield.

$$Y = 45{\cdot}8259\,R_2 - 3{\cdot}2908\,R_2^2 + 15{\cdot}0669\,R_3 + 16{\cdot}2298\,R_4 + 718{\cdot}5953\log_{10}R_6 + 1316{\cdot}9790\log_{10}R_7 + 4{\cdot}6697\,R_8 - 0{\cdot}0247\,R_8^2 + 9{\cdot}3667\,R_9 - 0{\cdot}0943\,R_9^2 - 3410{\cdot}2835 \quad \ldots\ldots(1)$$

where, Y = annual yield of made tea in kg/ha; R_2, R_3, R_4, R_6, R_7, R_8 and R_9 represent rainfall (centimetre) during November-December of the previous season, and January-March, April, June, July, August and September of the current season respectively. Ninety Nine per cent of the total variation in annual yield was accounted for jointly by these seven periods of rainfall. Contribution due to rainfall during October (R_1) of the previous season and May (R_5) of the current season was insignificant.

The study of the rainfall distribution and their type of relationship with the annual yield showed that in general, in almost all the years rainfall during November-December, January-March and April was much less than the rainfall upto which yield increased and on an average there were always deficiencies during these critical periods as shown in Table 11·01. On the other hand, on an average there were always excess rains during August and September (Table 11·01).

These results, therefore, suggest that if rainfall deficiencies are compensated by irrigation during dry periods and excess rain water is drained out during heavy monsoons as shown in Table 11·01, the annual yield of tea in the Southern part of Chalsa sub-district can be increased from 1522 to 2115 kilograms of made tea per hectare (Table 11·01). This is equivalent to about 39 per cent (593 kilograms of made tea per hectare) increase over the actual yield recorded for this part of the sub-district.

Following important points need be stressed in the interpretation and utilisation of the above results.

(i) *Gain in yield due to irrigation mainly will depend on the period of irrigation, quantity of water applied in each period and draining out the excess rain water during the critical monsoon periods as shown in Table 11·01.*

(ii) *The results presented here are related to the average soil-climatic conditions for the Southern part of Chalsa sub-district of Dooars. Therefore, if irrigation is proposed for any individual tea estate, it should be based on by a careful exa-*

*Southern part of Chalsa sub-district consists of Baradighi, Batabari, Sathkyah, Aibheel and Kilcott tea estates who are T.R.A. members at present.

mination of such factors as distribution of rainfall, soil type, depth of soil, etc., of the particular estate.

(iii) *Irrigation and drainage requirements suggested in Table 11·01 need to be tested by actual field experiments before large scale programme is taken up.*

SURVEY ON FIELD MANAGEMENT AND ENVIRONMENTAL FACTORS AFFECTING THE YIELD OF TEA

Darjeeling, West Bengal : The object of this survey with some results was reported in the Tocklai Annual Scientific Report, 1976-'77, pp. 65-67.

Table 11.01. *Rainfall distribution during critical periods and the estimated irrigation requirement with the corresponding expected yield Region : Southern part of Chalsa sub-district of Dooars*

Critical period	Rainfall in Centimetere			Type of relationship and turning point(cm) where applicable*	Irrigation requirement (cm)		Average yield of made tea in kg/ha		
	minimum	maximum	Average		Range	Average	Without irrigation	With irrigation (Estimated)	Gain due to irrigation
November to December (Previous Season)	0	18	4	LQ(+—) TP—7	0—7	3			
January to March (Current Season)	2	26	9	L (+)	0—24	17			
April (,, ,,)	1	30	18	L (+)	0—29	12			
June (,, ,,)	65	148	103	Log (+)	Uneconomic		1522	2115	593
July (,, ,,)	66	178	124	Log (+)	,,				
August (,, ,,)	34	160	96	Log(+—) LQ(+—) TP—95	Drain out excess rain-water				
September (,, ,,)	32	101	74	LQ(+) TP—50	,,				
Total irrigation requirement				→	0—60	32			

* L = Linear, LQ = Quadratic, Log = Exponential and TP = Turning Point.

Further analyses were carried out during the year and some important results are summarised below:

(i) Area

(a) **Land utilisation :** Out of 51 T.R.A. member estates as on *31st December, 1973*, these records were available for 44 estates covering nine sub-districts of Darjeeling. 83·97 per cent of total area suitable for tea was under tea plantation in 1969 and it remained practically constant upto 1973. This showed that practically no programme for further extension of tea was taken up during this five-year period. But, there was a scope for further extension of tea. This can be seen from Table 11·02, which shows the percentage distribution of land utilisation of total area suitable for tea for various purposes as on 31st December, 1973.

Table 11.02. *Utilisation of land of 44 member estates in Darjeeling for various purposes as on 31st December, 1973*

Item	Area	
	Actual (ha)	Per cent
1. Area suitable for planting tea :	12098	100
(*a*) Area under tea plantation	10159	83.97
(*b*) Area suitable for tea plantation :		
(i) available for extension	161	1.33
(ii) Ancillary purposes— under thatch, bamboo, forest and/or grow more food	1778	14.78
2. Area not suitable for tea plantations:	13964	100
(*a*) Area under layout factory, bungalows, quarters, labourer lines, jhoras, etc.	9384	67.20
(*b*) —under thatch, bamboo, forest, and/or grow more food	4580	32.80

It can be seen from the table (Table 11·02) that more sixteen per cent of the area suitable for tea might be available for extension of tea. Of course, out of that, 14.70 per cent area is not readily available for extension. However, 1.33 per cent area can be immediately extended and the remaining 14.70 per cent may be made available for extension depending on the requirement of thatch, bamboo, etc. Thereby, total tea production of Darjeeling can be increased if only this measure is taken up. About 32.80 per cent of the area not available for tea, used for thatch, bamboo, forest and grow more food, is not suitable for tea as such. Remaining 67.20 per cent of the area not suitable for tea, is used for factory, bungalows, staff quarters, labourer lines, hospital, roads, etc. Also there may be barren hills or jhoras flowing through the estates.

(b) **Land under different plant density :** About 40 per cent of area under tea in the member estates of Darjeeling planted with less than 7000 plants per hectare, and between 7000 and 10000 plants/ha covered about 42 per cent area. Whereas, only about 15 per cent area planted with above 10,000 plants/ha. Plant population of the remaining 4 per cent area is not known.

This clearly suggests that there is enough scope to increase the yield per unit area of replantations/extensions by using higher plant population.

(ii) Vacancy

It is very much alarming that there is no record of tea bush vacancies as high as 82 per cent of the area under tea.

Here again, this indicates that in order to increase the yield rate, either extensive infilling or suitable uprooting/replanting programme should be taken up with judicious planning.

(iii) Comparison of yield trend between T.R.A. member and non-member estates

A comparison of yield trend (three yearly moving average) between T.R.A. member and non-member estates from 1960 onwards is shown in Fig. 11.01.

From the figure (Fig.11.01) it can be seen that the average yield/ha of T.R.A. member estates is much higher than that of the non-member estates. It is interesting to notice that while member estates have been increasing their productivity, even non-member estates have benefited from indirect transfer of technology which can be seen from the figure (Fig.11.01) that non-member estates have started to increase their yield from 1966 onwards. Further, the higher yield of T.R.A. member estates suggests that to a great extent member estates are utilising the results of research.

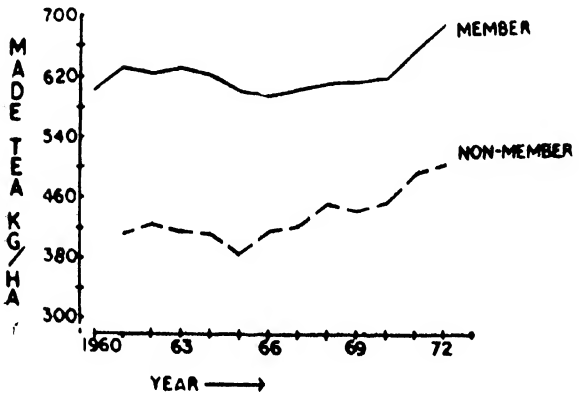


Fig 11.01. Yield trend for T.R.A. member and non-member Estate : Three moving average (Period : 1960-73.)

(iv) Effect of aspect, elevation, Nitrogen and their combinations on the yield of tea above 7 years old

The effect of aspect, elevation, Nitrogen and their combinations on the yield of tea above 7 years old showed that the yield level decreased with the increase in elevation at any one aspect. Similarly, yield varied from aspect to aspect on any one elevation, e.g., yield per hectare on East aspect at four elevations, *viz.*, 305—≤610 m, 610—≤915 m, 915—≤1220 m and 1220—≤1525 m (1000′—≤2000′, 2000′—≤3000′, 3000′—≤4000′ and 4000′—≤5000′ respectively) was higher than that on North aspect at the corresponding elevation. It was also found that on any one aspect the requirement of and the return in yield from a kilogram of Nitrogen decreased with the increase in elevation. Further, the requirement of Nitrogen and the return from the same were higher on East aspect than for tea on North aspect at each of these elevations (Table 11·03).

Table 11.03. *Effect of Aspect, Elevation, Nitrogen (Ground application) and their combinations on the yield of tea (Made Tea kg/ha) for above 7 years old*

Aspect	Elevation (in metre) \ Nitrogen (kg/ha)	15— ≤45	45— ≤75	75 - ≤105	105 ≤135
North	305— ≤610	701	796	—	—
	610 — ≤915	665	753	—	—
	915 - ≤1220	594	654	689	—
	1220 ≤1525	502	542	573	—
East	305— ≤610	879	1037	—	—
	610— ≤915	771	870	937	—
	915— ≤1220	709	792	854	892
	1220 ≤1525	621	688	747	770

The results suggest that quantity of Nitrogen does not appear to have been applied correctly.

(v) Effect of slope of the section, elevation, Nitrogen and their combinations on the yield of tea above 7 years old

In order to find out the effect of slope of the section on the yield of tea, sections were broadly divided into two groups, *viz.*, area of the sections having slope below 30° (Gentle Slope) and above 30° (Steep Slope) (Reference: Annual Scientific Report, 1976-77, p. 65).

The effect of slope of the section, elevation, Nitrogen and their combinations on the yield of tea above 7 years old revealed that yield level was adversely affected by the increase in angle of the slope of the section at any one elevation. It was also noticed that the requirement of and response to Nitrogen varied with the angle of the slope of the section at any one elevation as well as with elevation at any one angle of the slope of the section (Table 11·04). The reason for these variations needs thorough investigation.

The results show that there is a scope to increase the yield per hectare and even higher doses of Nitrogen would pay in certain situations of gentle slope and low elevations. On the other hand there is need to limit the rate of Nitrogen application at a point where it would

Table 11.04. *Effect of Slope, Elevation, Nitrogen (Ground application) and their combinations on the yield of tea (Made Tea kg/ha) for above 7 years old*

Slope	Elevation (in metre)	Nitrogen (kg/ha) 15— ≤45	45— ≤75	75— ≤105	105— ≤135
Gentle (0°– 30°)	≤ 305	863	1025	1195	1304
	305— ≤ 610	807	931	1031	—
	610— ≤ 915	780	885	952	—
	915— ≤1220	609	690	747	774
	1220— ≤1525	533	590	626	—
	1525— ≤1830	362	399	424	—
Steep (Above 30°)	305— ≤ 610	746	838	910	957
	610— ≤ 915	700	761	798	823
	915— ≤1220	548	596	622	640
	1220— ≤1525	496	535	558	570
	1525— ≤1830	316	344	—	—

not pay on steep slope or at higher elevation (Table 11·04).

(vi) Effect of shade, aspect, Nitrogen and their combinations on the yield of tea above 7 years old

It might be mentioned here that the shade was present in about 90 per cent area at elevation upto 610 m (2000′) while about 60 per cent tea was shaded at 1068 m (3500′) elevation and this particular study covered upto this elevation.

The effect of shade, aspect, Nitrogen and their combinations showed that shaded tea always gave higher yield than that of unshaded tea, but it was interesting to find that the beneficial effect of shade varied from aspect to aspect, e.g., it was more on South than North-West aspect. But, the return from a kilogram of Nitrogen was always higher from unshaded tea than that from shaded tea on both the aspects. It was also noticed that the requirement of Nitrogen varied between no shade and shade on any one aspect. It again varied under any one shade status at different aspects (Table 11.05).

Table 11.05. *Effect of Shade, Aspect, Nitrogen (Ground application) and their combinations on the yield of tea (Made tea kg/ha) for above 7 years old*

Aspect	Shade	Nitrogen (kg/ha) 15— ≤45	45— ≤75	75— ≤105	105— ≤135
South	No Shade	455	594	668	—
	Shade	737	820	876	907
North-West	No Shade	411	493	524	—
	Shade	566	606	628	—

These results suggest that there are instances of under and over application of Nitrogen, e.g., on South aspect under no shade, Nitrogen is likely to pay even beyond 90 kg/ha, whereas on North-West aspect with shade at 90 kg/ha, it is not likely to pay (Table 11·05).

(vii) Effect of pruning cycle, elevation and their combinations on the yield of tea above 7 years old

The effect of pruning cycle, elevation and their combination revealed that 3-year pruning cycle gave highest yield upto elevation 915 m (3000′), whereas 4-year pruning cycle gave maximum yield at elevation 915—≤1220 m (3000′—≤4000′), 5-year cycle at elevation 1220—≤1525 m (4000′—≤5000′), and at elevation between 1525 ≤1830 m (5000′—≤6000′) 6—year pruning cycle gave highest yield.

This result indicates that length of pruning cycle which gives maximum yield, is very much dependent on the elevation. This, however, needs thorough investigation.

(viii) Effect of pruning type, pruning cycle, Nitrogen and their combinations above 7 years old tea

The study showed that the yield decreased with the severity of cut in any one cycle and also varied between cycles in any one pruning type. It was also noticed that the return per kilogram of Nitrogen varied with the pruning types in any one cycle, as well as between cycles in any one pruning type.

The results indicate that the requirement of Nitrogen upto which it may pay, would vary from pruning type to type within a cycle and also between cycles within a pruning type. This aspect again needs thorough investigation.

This survey has thrown light that there is an ample scope to increase the total production by extension and per unit area yield in Darjeeling provided suitable field management practices are adopted under different agro-environmental conditions. It has also indicated that rate of Nitrogen application should be limited under different management and environmental conditions

where it would not pay, and increase in situations where optimum level is not being used at present.

It should form the basis of an extensive R & D programme to evolve package of practices for increasing the productivity of Darjeeling tea.

Detailed results will be published in a Tocklai publication.

JOINT RESEARCH PROJECT

The study on N, P and K requirements of mature tea conducted on 16 sites consisting of 32 experiments covering different agro-climatic regions of North East India and to find out the response surface, jointly with Advisory Department, continued during the year. The results so far obtained are reported in this report by the Advisory Department.

The study on rainfall data for different localities, jointly with Soils & Meteorology Department, to find out the type of distribution and to obtain the intensity duration curve of rainfall is in progress.

A comprehensive questionnaire has been prepared to collect data on various aspects annually from the member estates' records covering all the member estates of North East India in order to enable all the research workers of the Station to formulate the future advice and course of research for increasing the yield of tea and reducing the cost of production.

STATISTICAL SERVICE FUNCTION

A number of experiments were planned and designed during the year. The method of analyses was determined for a large number of experiments of various projects of the Station in order to achieve the objectives of the projects.

DATA PROCESSING ON THE UNIT RECORD MACHINES ON THE ELECTRONIC COMPUTER

Field and laboratory experimental records for 1976/77 on computerised proforma poured in practically from all the research departments and from the tea estates of North East India. Weekly/monthly/yearly yield and other experimental records for about 300 experiments were checked, punched and varified on the Unit Record Machines installed at Tocklai. Computations of about 350 experimental analysis were carried out on the Unit Record Machines and on the Electronic Computer during the period. In addition to these, computations of survey data and all accounts jobs were carried out on the Unit Record Machines.

Agricultural Economics

Data on area, production and yield for 1970-76 were received from 481 TRA member estates. The data were analysed to pinpoint constraint on productivity for improved advisory work. Average increase in yield was 3% per annum.

Data from 30 member estates showed that rejuvenation increase productivity in a short time and hence can be dovetailed with replanting programme to compensate the loss of crop from uprooting.

Motion & Time studies on plucking showed that effective time on a peak day varied from 3.8 hours to 5.7 hours for the workers and accounted for only 45% to 62% of time spent in the field. Further the fast pluckers were 26% more productive than the average pluckers and slow pluckers were 26% lower than the average pluckers.

Study on production, cost and price of tea industry in N.E. India for 43 years reflects the narrow margin of profit in the long term. Cost and price behave in cyclical nature.

Yield Trend analysis : An attempt is made first time to evaluate the yield trend of the TRA member estates. A proforma was issued to collect area, production and yield figures and percentage of recovery of made tea for the period 1970-76 to 687 TRA member estates, of which 481 member estates supplied the information. The yield trend of the district, sub-area and the estate concerned was worked out. The member estates were informed of their yield trend together with sub-area and the district. The increase in yield during the seven years period (1970-76) of 481 member gardens sub-area wise is evident from the data presented in table 12.01.

The variation in the yield within a sub-district may be due a number of factors, but it does certainly show the diversified problems that Tocklai R & D may have to deal with, even within the same sub-district. It may also show the yield potentiality (achievable) within a sub-district.

Table 12.01. *Area production and yield under different Sub-areas during 1970-1976*

Sub-areas	Repl Estates	1970			1976			% Increase over 170			Yield Increase at compound rate of
		Area Ha	Prod. '000 kg	Yield kg/ha	Area Ha	Prod. '000 Kg	Yield kg/ha	Area	Production	Productivity	
Assam South Bank	207	66310	94852	1430	69564	116479	1674	4.9	22.8	17.1	2.7%
Assam North Bank	83	29766	39515	1328	32266	54405	1686	8.4	37.7	27.0	4.2%
Cachar & Tripura	29	10626	10006	942	10994	12432	1131	3.5	24.3	20.1	3.1%
Darjeeling	38	9165	5425	592	9357	6303	674	2.1	16.2	13.9	2.2%
Terai	24	5448	6841	1256	5618	7938	1413	3.1	16.0	12.5	2.1%
Dooars	100	41443	60507	1460	42522	74235	1746	2.6	22.7	19.6	3.0%
Grand Total	481	162758	217146	1334	170321	271793	1596	4.6	25.2	19.6	3.0%

Both mature and young tea have made significant contributions for the increase in yield. A high level of management acumen and scientific planning in the application of new technology have played a dominant role in this achievement.

Economics of rejuvenation : Extension, Replantation and Rejuvenation are three major steps of development in tea industry. The basic question is whether rejuvenation is a supplement to replantation or a substitute for it. According to some it may be taken as a *substitute* to replantation but the fact is that under the agro-climatic conditions in N.E. India, it should be taken as only a *supplement* to replantation.

A study of economics of replantation and rejuvenation was taken up in 1975 but due to non-availability of data regarding rejuvenation, only economics of replantation was completed in Oct., '75 and presented in Tocklai Conference in Nov.,'75. During 1976-77, we collected data for the period 1967-1976, from 30 estates of Assam Valley, Dooars and Terai who had practiced rejuvenation on large areas.

The estates under study adopted two different systems of rejuvenation.

1. Rejuvenation with infilling and interplanting.
2. Rejuvenation with block infilling.

Under the first system, 24 estates rejuvenated the bushes, infilled the vacancies and reduced the spacing by interplanting with new plants. Under the second system, 6 estates rejuvenated the bushes and filled the vacancies in blocks.

The following important economic factors were taken into account for evaluating the benefits of rejuvenation

(a) Rejuvenation expenses
(b) Loss of crop due to heavy pruning
(c) Yield trend after rejuvenation
(d) Payback period

The rejuvenation expenses incurred during the 3 years (year of rejuvenation + 3 years) can be classified into two categoris:

(a) Rejuvenation, infilling and interplanting (RII and

(b) Rejuvenation and Block Infilling (RBI). The expenses per hectare were converted in kg of made tea using as steady value of Rs. 12/- for a kg of made tea (being the cost of production). These expenses are gien in table 12.02 & 12.03.

Table 12.02. *Rejuvenation expenses per hectare in kg made tea (KMTH) (November/December 1973 to 1976*

Operations	Average 30 estates	RII 24 estates	RBI 6 estates
1. Pruning & Indopasting	120.6	94.3	144.7
2. Uprooting	15.2	18.2	12.3
3. Levelling	20.8	32.3	10.2
4. Drainage	27.2	40.2	15.2
5. Manuring	283.1	260.4	303.8
6. Weed control	146.6	146.6	146.6
7. Pests & Disease control	57.8	79.1	38.2
8. Plants & planting	217.3	250.2	137.1
9. Shade plants & planting	16.8	23.6	10.7
10. Supervision	33.3	33.3	33.3
Total	938.6	978.2	902.0

Table 12.03. *Functional aspects of Rejuvenation expenses*

	Unit	Average 30 estates	RII 24 estates	RBI 6 estates
1. Labour	KMTH	351.4	357.7	345.4
	Mandays	(603)	(608)	(593)
2. Material	KMTH	553.9	587.2	523.3
3. Overhead	KMTH	33.3	33.3	33.3
Total	KMTH	938.6	978.2	902.0

Loss of Crop : In case of rejuvenation with infilling & interplanting (RII) the loss of crop was 49% in the first year, and 13% in the second year. In case of rejuvenation and block infilling (RBI) the loss was 44% in the first year only. The loss of crop in case of the former was more, since the yield did not reach the level of the average of the cycle before rejuvenation even in the second year, while in the case of the latter it crossed the pre-rejuvenation mark in the first year itself. The loss of crop in case of rejuvenation is substantially lower than in replantation (Fig. 12.02).

Yield Trend : The yield trends of the two rejuvenation systems are presented in Fig. 12.01.

The yield trend under rejuvenation with infilling and inter-planting (RII) shows a slower growth than rejuvenation with block infilling (RBI). In some cases, the cut across or deep skiffing treatment was given in the very first year after rejuvenation of RII sections, this resulted in a very slow growth of the bushes. Hence the yield was substantially lower than those left unpruned or light skiffed. The contribution from interplants could not be assessed separately.

The yield trend in both the cases is identical, but the difference is only in magnitude. However it is feared that in RII, there may be downward trend earlier than in RBI treatment.

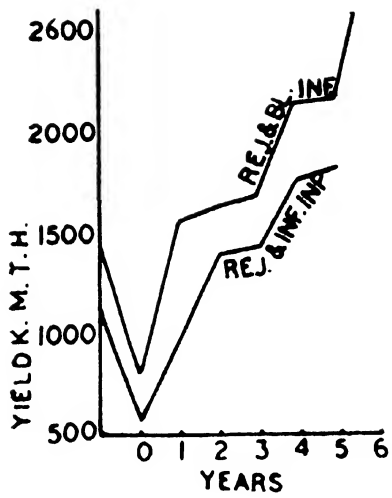


Fig 12.01. Yield Trend
(1) Rejuvenation with block infilling (RBI)
(2) Rejuvenation with infilling & interplanting (RII)

Payback Period : Results shown in Fig. 12.02 show that the payback period is identical i.e. the fourth year in both the cases, irrespective of the variation in yield trend.

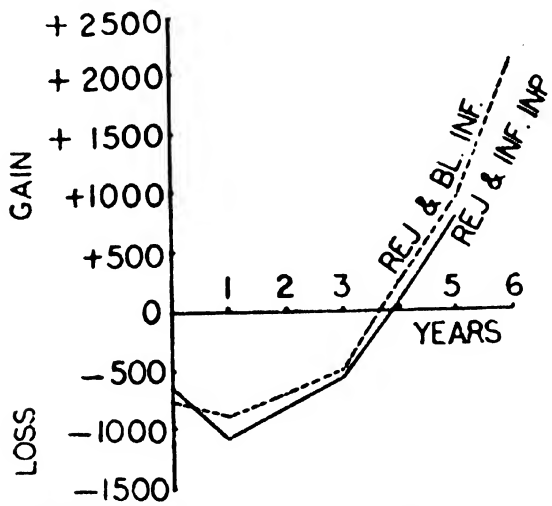


Fig 12.02. Payback for two methods of rejuvenation. All expenses and yield expressed for one hectare in terms of kilogrames made tea (KMTH)

Comparison of Rejuvenation and Replantation: A section becomes uneconomic, if it has a low break even yield. This calls for a decision for its improvement, either by rejuvenation, or by replanting. The economics of each differ widely.

The Table 12.04. shows the comparative per hectare expenses of rejuvenation and replantation, both expressed in kg made tea (KMTH). Replantation expenses are about three times higher than for either types of rejuvenation.

Table 12.04. *Comparative Cost of Rejuvenation and Replantation* (KM'TH)

	RII	RBI	Replanting
Expenses	978	902	2000
Loss of crop	690	617	2700
Total expenses	1668	1519	4700

Comparative benefits : Table 12.05 shows the comparative benefits of rejuvenation with block infilling replantation. The yield trend in both cases is estimated on the basis of the latest avilable data. In the case of replantation, two yield trends Rep. 'A' and Rep. 'B' have been shown to illustrate the effects on profits from this operation (replanting). It is felt that both types of trend are possible even with the existing technology.

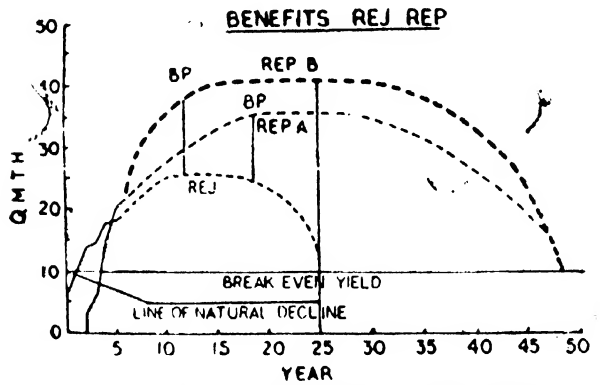


Fig 12·03. Comparison of benefits from rejuvenation and replantation

It is expected that rejuvenation benefits will last for 25 years before reaching the current break even yield of **10** quintals per hectare. Against this, the replantation benefit is expected to last at least fifty years, in both replantation 'A' and replantation 'B' before the yield drops to the same break even level.

The total benefit of rejuvenation based on data presented in Fig. 12.03. is estimated at 124.8 quintals of tea per hectare in 25 years where as replantation 'A' gives a net benefit of 488 quintals and replantation 'B', 611.5 quintals per hectare.

In the initial years, rejuvenation has an edge over replanting as the pay back period of rejuvenation is less than 4 years, where as replantation 'A' takes 8 years and replantation 'B' takes 7 years to cover the pay back period, without taking interest into account.

The table 12.05. shows the total expenses at line 8 and also the crop realised from the 1st year upto the year the yield drops to the break even level in line 9 for rejuvenation and in line 15 for replantation A & B. At the 26th year, when rejuvenation yield drops to break even, the benefits of rejuvenation, replantation A and replantation B are shown at line 9.

Table 12.05. *Total benefit and balancing point from rejuvenation and replantation (Quintal Made Tea per Hectare)*

		Trend	
	Rej.	Rep. A	Rep. B
1. Actual total yield at start	536	698	793
2. Deduct break even yield	260	260	200
3. Net yield	276	438	533
4. Deduct variable expenses at 50%	138	219	269
5. Contribution	138	219	269
6. Expenses for Rej./Rep.	9.7	20.0	20.0
7. Loss of crop	3.5	13.5	13.5
8. Total (6 + 7)	13.2	33.5	33.5
9. Net contribution in 26 years	124.8	185.5	235.5
10. Total benefit of Rep. over Rej. upto 25th year		60.7	110.7
11. Balancing point between Rej. & Rep.		$18\frac{1}{2}$	12
12. Total gain from 26th to 48th year		605	752
13. Deduct variable expenses		302.5	376
14. Contribution		302.5	376
15. Total benefit in 48 years (9+14)		488	611.5

Further replantation A gives 185.5 quintals, replantations B gives 235.5 quintals, whereas rejuvenation gives only 124.8 quintals of extra crop per hectare. This means that replanting, whether A or B, is more beneficial in the long run, even though it is more expensive initially.

However, there is a balancing point at which the benefits of rejuvenation & replanting are the same. This happens in 12 years with replantation B with a higher yield trend, and at $18\frac{1}{2}$ years with lower yielding replantation 'A' will affect the balancing point.

The yield level after replantig with improvement in cultural practices and quicker method of bringing up young tea, one could, however, expect higher replanting yields as in 'B' or even more. The development activity should, be geared to long-term measures, taking into consideration long-term benefits. As shown earlier, even the average yielding replantation is more remunerative than rejuvenation in the long run.

MOTION AND TIME STUDIES IN PLUCKING

With the contemplated growth of tea crop at an annual rate of nearly 3%, plucking of the crop will become a serious problem in the years to come-motion and time studies on plucking were, therefore, conducted with the following objectives :

1. To raise earnings of pluckers by increasing the efficiency of plucking.
2. To help in plucking additional crop.
3. To spot wasted time and effort.
4. To effect possible cost reduction.

Related factors : Factors that affect the speed of plucking, and the quantity of leaf plucked are :

1. Density of shoots or shoots available for plucking. This in turn, depends on yield of a section, jat, age of bushes, the spacing, the pruning treatment, and the vacancies in the section plucked.
2. The weather at the time of plucking.
3. The plucker's performance, which depends on the

natural speed of the plucker, age, physical fitness, height of the plucking table in relation to the height of the plucker, the weight of shoot plucked and its fineness, the duration of plucking, the motions involved, the distances to be travelled, use of baskets or jhoolies, etc.

Plucking efficiency : Table 12.06. shows the shoots plucked per minute, the weight of shoot, total leaf plucked per day, and the effective hours of plucking. The effective hours is the calculated time required for plucking the total leaf harvested in a day at the observed speed.

Table 12.06. *Indices of plucking efficiency in eight estates*

Estate	Shoots per min.	Shoot wt. in gms.	Leaf plucked in kg	Effective hours	Shoots plucked/ day
1	152	.75	30.6	4.5	35239
2	142	.93	42.7	5.4	46112
3	140	.81	36.6	5.4	36601
4	140	.71	32.4	5.4	45378
5	140	.94	30.2	3.8	32025
6	125	.85	36.2	5.7	42739
7	122	.82	23.9	4.0	29182
8	102	.89	25.6	4.7	28927

Effective and actual plucking hours

Table 12.07 shows the effective hours of plucking, the actual hours as observed, and the gross hours for which the workers was in the estate. The efficiency has been worked out as a percentage of the effective hours on the gross hours.

Table 12.07. *Effective and actual plucking hours*

Estate	Eff. hr.	Actual hr	Gross hr.	% Effective time
1	4.5	5.4	8.5	53
2	5.4	6.4	9.3	58
3	5.4	5.6	9.0	60
4	5.4	6.6	8.8	61
5	3.8	5.8	8.5	45
6	5.7	7.0	9.2	62
7	4.0	5.3	7.4	55
8	4.7	5.1	9.1	52

In the case of estates 3 and 8 the effective hours are very close to the actual hours suggesting an uniform standard of efficiency while under observation and at other times. The highest efficiency has come upto only 62%. The difference between the gross hours and plucking hours is the time including rest, spent on non-plucking work, like walking for weighment etc.

Plucker's time utilisation : Table 12.08 shows the details of the time utilisation by the plucker.

Table 12.08. *Break up of plucking time utilisation under a standard condition*

	Fast plucker		Slow plucker	
	Hour	Min.	Hour	Min.
1. Plucking time	7	28	6	28
2. Arrival time	0	10	0	10
3. Preparation time	0	7	0	7
4. Rest time	0	35	0	32
5. Weighment time	1	01	1	08
6. Departure time	0	5	0	10
7. Total time	0	26	8	35
8. Leaf plucked (kg)	0	46.6	0	23.1

The arrival, rest and weighment time varies in different estates and on different days. Arrival, depending on the distance between the plucking spot and the entry point, varied between 3 to 35 minutes. The rest time was taken in different spells, often along with the weighment breaks. Weighment time, depending on the distance walked and the number or weighments it varied from 40 to 105 minutes.

The slow plucker's output is lower due partly to less plucking time.

Fast, Average and slow pluckers : A comparison of three teams of fast, slow and average pluckers in teams of two each, was made. The results are shown in table 12.09. & 12.10.

Table 12.09. *Fast, Average and slow Pluckers performance in different estates*

	Fast		Average		Slow	
Estate	Shoot/ min	kg/hr	Shoot/ min.	kg/hr	Shoot/ min.	kg/hr.
1	210	8.0	166	5.6	123	5.2
6	207	12.0	146	8.5	102	5.8
2	156	8.2	148	7.2	114	5.9
4	196	8.1	144	6.2	93	4.7
3	187	6.3	96	5.1	73	3.8
7	163	8.8	137	6.8	67	4.0
5	123	7.6	120	6.0	93	4.5
8	123	6.3	96	5.1	73	3.8
Average	177	8.2	133	6.5	95	4.8

It is seen that fast plucker plucks one third more than the average plucker, and the slow plucker one third less as shown in Table 12.09

Table 12.09 (A) shows that a fast plucker gains 1.6 kg in August which is more conducive for higher plucking against only 1 kg day gains by an average and slow pluckers.

Table 12.10. *Pluckers performance in different months*

	Fast		Average		Slow	
Estate	Shoot/ min.	kg/hr.	Shoot/ min.	kg/hr.	Shoot/ min.	kg/hr.
July	164	7.1	117	5.8	84	4.1
August	184	8.7	138	6.8	96	5.1
September	179	8.3	139	6.7	101	5.1

By and large each category of female plucker *viz.* fast, average, and slow, plucks faster and harvests about 4% more weight than male pluckers. The effective plucking time showed no difference. This may not be applicable in all situations.

Plucking speed and plucking cost : The impact of speed of plucking on plucking cost is shown in Table 12.11.

The plucking cost includes plucking at 18 paise per kg, daily incentive at Rs. 1.28, other fringe benefits like food subsidy, protective clothing, dry tea etc, and also a share of the Sirdars' wages and fringe benefits.

Table 12.11. *Relationship between plucking cost and plucking speed*

	Fast	Average	Slow
1. Quantity plucked in 5 hours (kg)	41	32.5	24
2. Quantity plucked % with average	126	100	74
3. Wage cost in price/kg	170	185	212

Results and suggestions : In order to achieve the benefits of work study in practice, each estate will have to conduct the study in their own estate. It was understood from the participating estates that no specific training is given to the pluckers, who mostly start plucking in their teens. They learn the trade from the existing pluckers.

The work study helps in measurement of (a) True efficiency (b) Wasted motions (c) Non-plucking time and (d) Effects of related factors.

The suggestions for implementation are (a) Set targets (b) Train pluckers (c) Reduce wasteful motions (d) Reduce non-plucking time and (e) Carry out occasional time studies.

DYNAMICS OF PODUCTION, PRICES & COSTS IN TEA INDUSTRY

The contemplated growth in crop of tea in coming years needs a close study of the economic forces affecting the commercial aspects. Table 12.12. shows the growth trend of the crop and price tea from 1933 to 1976.

Table 12.12. *Relationship between crop and price a long range study*

Year	Crop tons × 1000	Price Paise/kg
1933	182	90
1938	199	99
1943	228	177
1948	261	344
1953	291	437
1958	318	484
1963	357	519
1968	389	584
1970	419	655
1971	435	679
1972	456	654
1973	472	685
1974	490	1004
1975	487	1074
1976	512	1232

Source Tea Statistics
Correlation between crop and price
$r = 0.94$ ***
$100\ r^2 = 88\%$
(*** Significant at 0.001% level of probability)

Demand of tea both in the domestic and foreign markets has continuously been increasing. This has led to increase in price. Due to increase in price, industry made serious efforts to increase the crop.

Table 12.13 shows the cost and price movements from 1933.

Costs & Price have been chasing each other very closely. The increase in cost has led to increase in price & vice versa.

Table 12.13. *Price and cost trend in tea industry of India in different years*

Year	Price (Paise/kg)	Cost (Paise/kg)	Difference (P-C) Paise/kg
1933	90	98	— 8
1938	99	104	— 5
1943	177	145	+ 32
1948	344	266	+ 78
1953	437	260	+ 77
1958	484	529	— 45
1963	519	519	-
1968	584	517	+ 67
1970	655	546	+ 109
1971	679	656	+ 23
1972	654	765	—111
1973	685	819	—134
1974	1004	851	+ 153
1975	1074	961	+113
1976	1232	1000	+ 232

Source : Economics of Tea Industry in India; Dr. R. C. Awasthi & Tea Statistics.
Correlation between Price and cost

$r = 0.95$ ***
$100r^2 = 90\%$
(*** Significant at 0·001 % level of probability)

It further shows that the cost has been higher than sale price for periods between 1953 and 1973. The cost has been increasing at an average of $22\frac{1}{2}$ paise per year whereas the sale price has been increasing during the same periods only by $15\frac{1}{2}$ paise, till the price overtook the cost by a big leap, late in 1973.

Fig. 12.04 shows the fluctuations in the trend of net income (price less cost), during 43 years period (1933 to 1976). Each time the net income line moved into profit zone shown, the profit neutralised the previous losses partly only, because of the levy of taxation, payment of bonus, and declaration of dividends. A close study of the cost increases indicates its direct link with wage increases, and in recent years, increased prices of fuel, manure etc. On the other hand, price is mostly dependent on external factors of world demand and supply and price competition. In this context a systematic study of dynamics of costs is imperative if production increase is to be assumed, maintaining the economic viability of the industry.

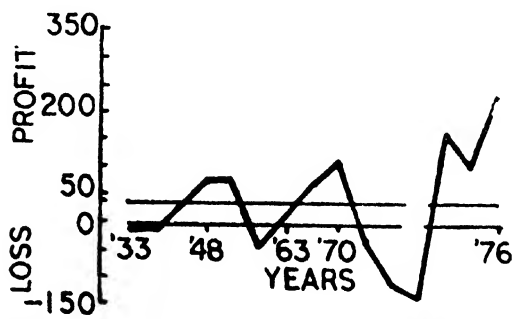


Fig 12.04. Net Income (Price less cost) variations 1933 to 1976

Plucking wage cost for Assam Valley : The wage rates changed as per revised agreement with the workers w.e.f. 1st March, 1977. The minimum wage rate increased to Rs. 4.80 per day with effect from 1st March,

'77. The plucking wages are increased from 12 paise to 18 paise per kg green leaf. The daily incentive is reduced to Rs. 1.28 per day. This will increase by 50 paise each year for the next two years.

The workers receive fringe benefits with each wages. The two types of fringe benefits (a) benefits variable with wages and (b) benefits related to employment, are given to the workers. The variable fringe benefits are 31.33 per cent of wages. It will remain the same with the increase in wages. The fringe benefits related to employment may change with the change in price of articles. The quantum of fringe benefits may vary in certain estates within Assam Valley itself.

The variable fringe benefits calculated for all the items is $33\frac{1}{3}\%$. At the present rate of Rs. 4.80 per day per worker, it is Rs. 1.51 plus the fringe benefits related to employment in the form of food subsidy, housing, medical expenses, firewood, dry tea, protection clothing, creche and water supply etc. come to Rs. 3.29. Thus the total wages are Rs. 9.60 per day. Only minimum bonus of 8.33% was taken for calculating variable fringe benefits, the variable fringe benefits will increase with the amount of bonus.

A formula for calculation of plucking cost in relation to plucking/day was worked out and published in 'Two and a bud' vol. 24 No. 2 Dec., 1977. The formula is illustrated below for four cases of plucking and the cost per kg of net saleable tea is given under each example. Tea made is taken at 22%.

Table 12.14. *Plucked leaf and cost at different levels*

	I	II	III	IV
Kg plucked per day	25	40	40	60
Pluking cost per kg of	209	172	161	151
Net saleable tea Ps.				

Economics of manuring : The data collected during 1976-77 from 97 member estates of 950 sections planted/replanted during the last 25 years were collected in two parts.

Part I was garden sheet analysis which was completed in 1976-77 and Part II comprised of sectional sheets which were re-arranged, and classified on the basis of sub areas and year of planting/replanting. The tabulation and analysis work is to start shortly.

Techno-Economic study : The department undertook Techno-Economic Study of one garden in the Dooars. Agricultural Economist with Cost Advisor and Advisory Officer, West Bengal visited the garden and collected necessary data. A detailed report was prepared and submited to the Directors. Some more enquiries have been made by member estates and the department may undertake limited hnumberof Techno-Economic Studies, not more than two, during 1978-79.

Tea economics courses : The department conducted two courses on 'Tea Economics' of two days' duration in June & July, 1977. The topics included in tea course are given below :

1. Profit Planning
2. Input Costs
3. Output costs
4. Financing
5. Budgetory control
6. Break [illegible] concept
7. Development projects
8. Productivity

The course was inaugurated by Mr. H. W. Butterwick who also delivered the first lecture on Profit Planning. Mr. J. P. F. Furst delivered the lecture on 'Profit Planning, during the second course. The faculty was mainly from Tocklai itself -Dr. R. C. Awasthi, Agricultural Economist, Mr. N. S. Venkatakrishnan, Cost Advisor, and Dr. N. K. Jain, Director. It was supplemented by one of the Economic Advisory Committee members Mr. P. K. Bose, Duncun Bros., Calcutta for the first course.

The courses received good response from the member companies and tea estates. Participants included superintendents, group managers, managers and Assistant managers in the two courses.

The course material was distributed in advance amongst the participants. The topics discussed in the courses were appreciated by the participants, as expressed by them in answer to a questionnaire issued to each at the completion of the courses.

Library and Publication

General

The Central Reference Library supplied regularly books and other publications to the eleven departmental libraries at Tocklai and five out-station branch libraries. Requisition for books and journals for Scientist of Tocklai and out-stations increased this year. Five new journals were added to the library thus making a total of 148 journal heads. In addition 105 journals are received in exchange of Tocklai publications.

The library hours have been extended after office hours from 3-30 to 5-30 p.m. for the benefit of the Scientist of Tocklai Campus.

Arrangement is being done to fill up the vacancy of the Cataloguer and to appoint one typist to help in the increased documentation and information works.

The Tocklai Central Library staff rendered technical services to the Tocklai Childrens' Library and Jorhat Gymkhana Club Library beyond office hours.

The Documentation Assistant was sent to Delhi in January 1978 for training in documentation for one month and to Karnataka in November 1977 to attend IASLIC Conference.

Library Service

The Science students of graduate and post-graduate classes of Assam Agricultural University, Gauhati University, Lecturers of J.B. College, Bahana College, Sibsagar College, Scientists of Regional Research Laboratory, Jorhat, One Year's Trainee, V. P. Trainees of T.R.A. Member Estates, Trainees from Mauritius and a few research fellows in addition to Tocklai Scientists utilised the Library during the year. More than 100 papers of photocopies of important and rare documents were printed by the Tocklai reprographic Unit and supplied to Director T.R.I. East Africa and members of T.R.A.

Library Statistics

The following were received in the Library during the year under review :

Book added during the year	..	154
Periodicals & Journals	..	1476
New Journals added	..	5
Pamphlets and Bulletins	..	580
Photocopy	..	3
Reprints	..	19
Filmstrips	..	2
Publications Consulted in Library	..	3850
Publications Issued to Departments		2036
Books bound during the year		224

Documentation & Information

In addition to weekly accession list of books & periodicals received in the library "Bulletin of Documentation on Tea" and twelve "Documentation list" containing articles on applied science published different scientific journals & periodicals were circulated during the year.

A classified subject-index of *Two & A Bud* has been prepered and ready for printing & circulation.

The bibliography on tea has been compiled and will be arranged in alphabitical order for printing & circulation.

The glossary/dictionary of tea terms is also being taken up and will be completed in the next few months.

The classification & cataloguing of books are in progress.

The Regional Union Catalogue Project of INSDOC for North Eastern Region has been taken up and for the project more than a dozen libraries have been visited by the Documentation Assistant to initiate compilation works. Catalogue of holdings of Tocklai library has also been complied under the above project.

Paper cuttings relating to tea and other important topics are being continued and information files increased during the year. Innumerable reference questions were answered and informations regarding tea, trade and industry were supplied to the scientists and members of T.R.A.

PUBLICATION

The activities of the Publication Section continued to be increased this year. Compilation & proof reading of Tocklai News, Annual Scientific Reports, Two & A Bud were done by the Publication Section with limited staff. One more staff in the Publication section will ease the situation.

The following publications were issued from Tocklai during the year.

1. (a) *Two & A Bud*, Vol. 24, Nos. 1 & 2
   (b) *Tocklai News*, Nos. 5 & 6

2. Memorandum

(a) No. 28 (Revised): Catchment Planning and Contour Planting for Safe Water Disposal, Water and Soil Conservation in the Plains Areas of North-East India, by—W. J. Grice.

(b) No. 30 (New) : Shade Trees Green Crop and Cover Crop Plants in the Tea Estates of N.E. India, by—A.C. Dutta.

3. Occasional Scientific Papers

(a) No. 10 : An Approach for Studying Ground-water Problems in the Tea Q-Estates, by—S.K. Dey and J. C. Cavelaars.

(b) No. 11 : Nitrogen Manuring of Mature Tea, by F. Rahman.

4. Special Bulletin

No. 9 Soil and Climatic Conditions of Sibsagar and Nowgong Tea Districts, by S. K. Dey, R. C. Chakravarty, P. Ghosh & Deepa Saikia.

5. Miscellaneous Reports

(a) Annual Scientific Reports for 1976-77

(b) Enginering Research & Development Department Quarterly Reports for quarter ending 30th June, 30th Sept., 31st December 1977 and 31st March, 1978.

(c) Proceedings of the Twenty Eighth Conference held at Tocklai on November 24 through November 26, 1977.

Appendix - A

LIST OF EXPERIMENTS CONDUCTED IN THE MEMBER ESTATES BY ADVISORY DEPARTMENT

South Bank

Project	Site	Index No.	Year of starting
NPK manuring of mature tea	Panitola	As. 108	1973
-do-	Thowra	As. 111	,,
-do-	Rupai	As. 114	,,
-do-	Diffloo	As. 120	,,
-do-	Meleng	As. 142	1976
Foliar application of zinc	Panitola	As. 109	1973
Shade in relation to tea nutrition	Thowra	As. 110	,,
-do-	Bordubi	As. 113	,,
-do-	Methoni	As. 119	,,
Plucking Experiment	Nahortoli	As. 126	1974
-do-	Lohpohia	As. 133	,,
Infilling Experiment	Halmari	As. 129	,,
Rejuvenation Experiment	Tara	As. 128	,,
-do-	Teloijan	As. 130	,,
-do-	Dilli	As. 160	1978
Cultivation Experiment	Deohall	As. 134	1975
Young Tea Manuring (YTD)	Fatikjan	As. 144	1976
-do-	Meleng	As. 145	1977
Young Tea Manuring (Response Surface NPK)	Balijan (H)	As. 153	1978
-do-	Sepon	As. 161	1978
Micronutrient Trial	Dilli 18	As. 154	1977
-do-	Dilli 5	As. 155	,,
-do-	Dilli 9	As. 156	,,
-do-	Daimukhia-9	As. 157	,,
-do-	Daimukhia-5	As. 158	,,
-do-	Daimukhia-13	As. 159	,,
-do-	Meleng	As. 162	,,
-do-	Sycotta	As. 163	,,
-do-	Dhekiajulli	As. 164	,,
-do-	Borsapori	As. 165	,,
-do	Bokakhat	As. 166	,,
-do-	Methoni	As. 167	,,

North Bank

NPK manuring of mature tea	Monabarrie	An. 116	1973
-do-	Naharani	An. 123	,,
Shade in relation to level of tea nutrition	Partabghur	An. 118	,,
Rejuvenation	Kacharigaon	An. 135	1974
-do-	Tezpur-Gogra	An. 136	,,
-do-	Baghmari	An. 137	,,
Infilling	Kacharigaon	An. 140	,,
-do-	Baghmari	An. 141	,,
Nitrogen with and without mulch	Sessa	An. 138	1975
Plucking and Pruning	Dhoolie	An. 139	1974
Micronutrient Trial	Durrung-1B	An. 146	1977
-do-	Durrung-1A	An. 147	,,
-do-	Singrijan	An. 148	,,
-do-	Tarajulie-2	An. 149	,,
-do-	Tarajulie-22	An. 150	,,
-do-	Tarajulie-19	An. 151	,,
Spacing Trial	North Bank	An. 152	,,

Cachar, Assam

NPK Manuring of Mature Tea	Silcoorie	C. 38	1973
-do-	Longai	C. 39	,,
Clonal responses to N in different agro-climatic region	Coombergram	C. 20	1962
Rejuvenation	Isabheel	C. 47	1974
Plucking & Pruning	Hattikhira	C. 45	,,
-do-	Silcoorie	C. 46	1975
Young Tea Manuring (YTD)	Borojalingah	C. 49	1977
Young Tea Manuring (Response surface NPK)	Arcuttipora	C. 50	,,
Bringing up of young tea (studies on frame development)	Arcuttipore	C. 51	1977
Micronutrient Trial	Issabheel-4	C. 52	,,
-do-	Issabheel-7	C. 53	,,
-do-	Issabheel-11	C. 54	,,

Dooars & Terai (West Bengal)

NPK Manuring of Mature Tea	Bagrakota	D. 55	1973
-do-	Sam Sing	D. 56	,,
-do-	Nimtijhora	D. 57	,,
-do-	Gungaram	Tr. 7	,,
Nitrogen Fertilizer	Baradighi	D. 33	1962
Clonal response to N in different agro-climatic region	Nya Sylee	D. 24	,,
Cultivation & Weed Control	Chuapara	D. 42	1970
Shade & Nutrition	Gandrapara	D. 50	1973
Infilling	Kartick	D. 41	1969
-do-	Jainti	D. 40	,,
-do-	Fagu	D. 37	,,
-do-	Sahabad	Tr. 4	,,
-do-	Mohurgong & Gulma	Tr. 3	,,
Rejuvenation	Dalgaon	D. 43	1972
-do-	Metelli	D. 44	,,
-do-	Killcott	D. 45	,,
-do-	Rydak	D. 46	,,
-do-	Kumlai	D. 47	,,
-do-	Gungaram	TR. 5	,,
Plucking & Pruning	Birpara	D. 58	1974
-do-	Dalsingpara	D. 59	,,
-do-	Hansqua	TR. 60	,,
Clone vs Nitrogen Trial	Nagrakata	D. 48	1973
Irrigation	Dam Dim	D. 63	1976
Longterm Trial	Nagrakata	D. 61	1974
New Long term trial	Nagrakata	D. 62	1975
Young Tea Manuring (YTD)	Nagrakata	D. 65	1977
-do-	Nagaisurrie	D. 66	,,
Young Tea Manuring (Response surface NPK)	Rydak	D. 67	1978
-do-	Lakhipara	D. 68	1977
-do-	Bhogotpore	D. 69	1978
Bringing up young tea	Haldibarie	D. 70	1977
Micronutrient Trial	Bharnabari-5	D. 71	1977
-do-	Bharnabari-6	D. 72	,,
-do-	Bharnabari-7A	D. 73	,,
-do-	Crassmore	D. 74	,,
-do-	Nagrakata	D. 75	,,
-do-	Bhogotpore	D. 76	,,

Darjeeling

NPK Manuring of Mature Tea	Chongtong	Dj. 34	1973
-do-	Nagri Farm	Dj. 35	,,
Nitrogen Fertilizer	Lingia	Dj. 29	1967
Clonal response to N in different agro-climatic region	Nagri Farm	Dj. 19	1961
P & K with and without weedicide	Chamong, Sungma, Nagri	Dj. 31	1970
Infilling	Bannockburn	Dj. 36	1974
Rejuvenation	Bannockburn	Dj. 38	,,
Young Tea Manuring	Grelli	Dj. 48	1978
NPK Young tea response surface	Phoobsering	Dj. 47	,,
Micronutrient Trial	Ringlong	Dj.43 & 44	1977
-do-	Balasun	Dj.45 & 46	,,
-do-	Goomtea	Dj.41 & 42	,,
-do-	Maharani	Dj.40	,,

Appendix - B

LIST OF EXPERIMENTS CONDUCTED IN THE MEMBER ESTATES BY THE OTHER DEPARTMENTS

BOTANY DEPARTMENT

List of Estates under clonal selection scheme

Sl. No.	Name of Estate	Year of starting
South Bank, Assam		
1.	Heeleakah	1972
2.	Duklingia	1973
3.	Basabari	1974
4.	Borbam	1975
5.	Dahingiapara	1975
6.	Sotai	1975
7.	Bukhial	1975
8.	Dilli	1976
9.	Cherideopurbat	1976
10.	Tingalibam	1976
11.	Longboi	1976
12.	Dinjan	1976
13.	Gabru Purbat	1976
14.	Halwalting	1977
15.	Amgooric	1977
16.	Mokrung	1977
17.	Gatoonga	1977
18.	Rungamatty	1977
19.	Neghriting	1977
20.	Dooria	1977
21.	Gopalkrishna	1977
22.	Amluckie	1977
23.	Diju Valley	1977
24.	Gouranga	1977
25.	Kaliapani	1977
26.	Teloijan	1977
27.	Deepling	1977
28.	Borsillah	1977
29.	Namburnadi	1977
30.	Dalowjan	1977
31.	Borkatoni	1977
32.	Monohari	1977
33.	Lengrai	1977
34.	Sangsua	1977
North Bank, Assam		
1.	Durrung	1975
2.	Birjhora	1976
3.	Nagrijuli	1976
4.	Dhunseri	1976
5.	Tarajuli	1976
6.	Gingia	1976
7.	Halem	1976
8.	Chapar	1976
9.	Choibari	1976
10.	Kokrajhar	1976
11.	Mornoi	1976
Cachar, Assam		
1.	Chandighat	1976
2.	Burtoll	1976
3.	Peloi	1976
4.	Narsingpore	1976
5.	Longai	1976
Dooars & Terai, West Bengal		
1.	Gopalpur	1976
2.	Chuapara	1976
3.	Central Dooars	1976
4.	Kartick	1976
5.	Rydak	1976
6.	Leesh River	1976
7.	Baintgoorie	1976
8.	Birpara	1976
9.	Garganda	1976
10.	Subhasini	1976
11.	Dalsingpara	1976
12.	Engo	1977
13.	Samsing	1977
14.	Aibheel	1977
15.	Newland	1977
16.	Tirrihana	1976
17.	Mohorgong & Gulma	1976
18.	Bijoynagar	1976
19.	Panighatta	1976
Darjeeling, West Bengal		
1.	Happy Valley	1975
2.	Soom	1975
3.	Lingia	1975
4.	Balasun	1975
5.	Singbuli	1975
6.	Goomtee	1977

ENTOMOLOGY DEPARTMENT

Sl. No.	Experiments	Location of estate	Site	Index No.	Year started
1.	Effect of microclimate on mites	South Bank	Dooria	6	June, 1977
2.	Effect of longer pruning cycle on mites	South Bank	Gobindpur	6	June, 1977
3.	Effect of Foliar application of Looper caterpillar	Dooars	Meenglass	6	April, 1977
4.	Studies on the field incidence of Looper caterpillar	South Bank	Dooria	6	February,1977
5.	Effect of longer pruning cycle on Thrips	Dooars	Nagaisuree	6	March, 1977
6.	Studies on the seasonal incidence of scale insects	South Bank	Cinnamara	6	March, 1977
7.	Susceptibility of clones to Cockchafer	Dooars	Baintgoorie	6	April, 1977
8.	Studies on distribution and abundance of shot hole borer	South Bank	Sycotta / Moubund	6	March, 1977
9.	Susceptibilities of clones to Tea Helopeltis	South Bank	Namdang	6	—
10.	Survey of shade tree pests	Dooars	Kadamini / Cooch Behar	6	Nov, 1977
11.	Studies on the incidence of shade tree pests	South Bank	Dooria / Gobindpur	6	April, 1977
12.	Testing of nematicides (Prophylactic trial)	Dooars	Kartick & Satali	6	Dec, 1977
13.	Nematicidal control trial in Nursery (Palliative trial)	North Bank	Tarajuli	6	June, 1977
14.	Purple mite control trial	Dooars	Aibheli	6	March, 1977
15.	Cockchafer control trial	Dooars	Batabari	6	Sept, 1977
16.	Red spider control trial	Dooars	Meenglass / Gobindpur	6	March, 1978
17.	Looper control trial	North Bank	Durrung	6	May, 1977
18.	Helopeltis control trial	South Bank	Namdang	6	June, 1977
19.	Termite control trial	South Bank	Khongea	6	January, 1977

MYCOLOGY DEPARTMENT

Sl. No.	Experiment	Location	Site	Index No.	Year of starting
1.	Evaluation of different formulation against red rust	South Bank	Bokahola	MR 024	1977
2.	Effect of different concentrations of copper fungicide on red rust when applied with a power sprayer	South Bank	,,	MR 025	1977
3.	Screening of fungicides against black rot in pruned tea	,,	Desam	MB 017	1977
4.	Screening of fungicides against black rot in skiffed tea	,,	,,	MB 018	1977
5.	Effect of different concentrations of copper fungicides on black rot when applied with a power sprayer	,,	,,	MB 019	1977
6.	Screening of fungicides against blister blight	Darjeeling	Phoobsering	MF 008	1977
7.	Effect of different treatments on the control of blister and yield return	,,	Arya	MF 005	1976
8.	Chemical control of primary root disease	South Bank	Nahorkutia	MP 002	1974
9.	-do-	South Bank	Borhat	MP 003	1975
10.	-do-	North Bank	Tarajuli	MP 004	1973
11.	-do-	-do-	Thankurbari	MP 006	1975
12.	-do-	Darjeeling	Balsaun	MP 005	1974
13.	-do-	South Bank	Dilli	MP 007	1976

ENGINEERING DEPARTMENT

Sl. No	Experiment	Place
1.	Trial of Continuous Tea Roller	Meleng
2.	Trial of withered Leaf Preconditioner	,,

AGRONOMY DEPARTMENT

Sl. No	Experiment	Place	Year
1.	Effect of diuron application on young tea (concluded)	Amgoorie	1977
2.	Cultivation experiment in collaboration with Advisory deptt. continuing	Hatimara	1977

BIO-CHEMISTRY DEPARTMENT

Sl. No	Experiment	Place	Year
1.	Fermentation test conducted in the tea factories of	1. Cinnamara 2. Hunwal 3. Sycotta	1977

Appendix-C

PUBLISHED PAPERS & PAPERS IN THE PRESS

Jain, J.C., Choudhury, M.N.D, Bajaj, K.L. & Mathur, N.K. 1978. Some applications of Polystyrene Sulphanic Acid Resins. *Proc. of the Ion Exchange Symposium held in February'78 at Central Salt and Marine Chemical Research Instt., Bhavanagar pp. 31.*

(Abs. Polystyrene sulphonic acid resins, because of their unifunctional character have been widely used for laboratory work. The Amberlite resin IR-120 (H) has been used for the removal of excess of lead in the determination of water-soluble carbohydrates in tea leaf. This method is reproducible and suitable for routine analysis. The same resin has also been used for the removal of anions present in the pectin moieties prepared from tea leaf. The use of polystyrene sulphonic acid resins (Dowex 50W-X8 Mesh size 20-50US) as an acid catalyst has been developed for the acylation of aminoacids. In view of the advantages of use of resin over conventional methods, two types of reactions using resin have been studied. First type deals with the modification of —COOH group by esterification and the other related to the acylation of—OH group in hydroxy aminoacids.)

Manivel, L. & Muthukrishnan, C.R. 1977. The effect of Soil Application of NPK on the Fruitfulness of Buds in the Anab-E-Shahi Grape Variety. *Madras agric. J. 64 (7): 463-466, July.*

(Abs. N.P.K. fertilizers were applied to Anab-e-Shahi vines, sepearately and in combination about two weeks prior to fruitbud initiation. The buds were collected after the harvest of the crop and observed microscopically for fruitfulness. The nutrients, K in the basal region and P in the distal region of the cane had increased the fruitfulness of buds significantly. Higher percentage of fruitfulness was observed in the nodes 8, 9 and 10 as against the usual positions 3-5 nodes in the locality. The length to widh ratio of the cluster primordia was inversely proportional to the number of fritful buds in a cane.)

Dey, S.K. & Gohain, K.K. 1978. Effect of phosphate mulch and chemical weed control on production of feeder (absorbing) roots, uptake of phosphate by tea and available soil phosphate. *Proc. Symposium on Plantation Crops, Kottyam, Kerala, on 20-23 March, (in press).*

Singh, B. & O'Callaghan, J.R. 1977. Effect of interflow on Soil Drainage. *J. agric. eng. res.* (in press)

Singh, B. & O'Callaghan, J.R. 1977. Non-steady Drainage in a layered soils. *J. agric. eng. res.* (in press)

Singh, B. & O'Callaghan, J.R. 1977. Finite Element Solution to the Problem of Drainage of layered soils. *J. agric. eng. res.* (in press).

Appendix - D

SUMMARY OF METEOROLOGICAL OBSERVATIONS DURING 1977

Table 1. Tocklai (Mid Assam)

Latitude 26°47' N — Longitude 94°12' E — Altitude 96.5m (a.m.s.l.)

Months 1977	Daily temperatures °C					Rainfall (mm)		Daily sunshine hrs.	Daily Soil Temp. °C (under grass)			Monthly evaporation (mm)	
	Mean Max.	Mean Min.	Mean	Highest Max.	Lowest Min.	Monthly total	Rainy days		Depth 5 cm	15 cm	30 cm	Open pan	Pen-man
January	21.3 (22.4)	10.0 (9.4)	15.6 (15.9)	24.2	6.0	37.9 (21.3)	6(5)	5.7 (5.9)	17.4 (18.6)	17.4 (18.2)	18.3 (19.0)	32.8	58.4
February	24.6 (24.0)	12.3 (11.9)	18.4 (18.0)	27.4	7.0	37.1 (32.1)	8(8)	7.3 (6.2)	20.0 (20.4)	19.4 (19.8)	19.8 (20.2)	50.7	84.9
March	27.9 (27.5)	17.0 (15.5)	22.4 (21.5)	31.5	13.3	76.9 (79.2)	10(11)	6.9 (6.7)	23.8 (24.0)	23.3 (23.1)	23.5 (23.1)	79.0	129.0
April	25.8 (28.7)	19.6 (19.0)	22.7 (23.8)	30.8	17.1	443.2 (192.1)	23(16)	3.7 (5.9)	24.7 (26.8)	24.5 (25.8)	24.4 (25.6)	67.4	111.9
May	28.8 (29.9)	21.5 (21.8)	25.2 (25.8)	32.9	18.5	625.6 (278.3)	21(20)	5.6 (5.0)	27.8 (28.7)	27.2 (27.8)	26.9 (27.6)	95.7	153.5
June	29.6 (31.5)	23.8 (24.1)	26.7 (27.8)	34.5	20.5	291.8 (330.5)	21(23)	3.7 (4.5)	29.5 (30.6)	28.8 29.7)	28.7 (29.6)	80.3	134.8
July	32.6 (32.2)	25.6 (24.6)	29.1 (28.4)	34.5	23.5	421.8 (330.6)	24(25)	5.3 (4.7)	32.0 (31.4)	31.3 (30.6)	31.2 (30.6)	103.6	168.1
August	31.6 (32.0)	25.1 (24.6)	28.4 (28.3)	34.7	21.8	419.2 (344.6)	22(23)	5.2 (5.1)	31.2 (31.4)	30.8 (30.6)	30.9 (30.6)	92.1	156.2
September	31.8 (31.2)	24.9 (23.9)	28.4 (27.6)	35.5	22.2	134.7 (255.1)	16(19)	5.4 (5.1)	30.7 (30.8)	30.3 (30.2)	30.4 (30.2)	81.8	139.9
October	28.4 (29.3)	20.6 (21.0)	24.5 (25.2)	31.8	16.5	181.3 (117.6)	12(12)	5.7 (5.6)	27.3 (28.4)	27.2 (28.0)	27.8 (28.4)	61.1	113.0
November	25.9 (26.3)	16.3 (15.3)	21.1 (20.8)	29.4	12.3	19.5 (27.6)	6(4)	5.8 (6.1)	23.4 (24.0)	23.3 (23.7)	24.0 (24.6)	40.6	79.4
December	22.9 (23.3)	12.4 (10.6)	17.7 (17.0)	25.3	8.6	18.7 (11.1)	5(3)	5.9 (6.0)	19.6 (19.7)	19.8 (19.5)	20.8 (20.6)	31.4	58.9

PER CENT RELATIVE HUMIDITY

Table 1(a). Tocklai

Hours of Observations IST	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
0613	94 (96)	92 (94)	91 (92)	94 (91)	94 (92)	93 (92)	90 (93)	92 (94)	93 (95)	95 (96)	95 (96)	96 (96)
1313	59 (57)	49 (54)	55 (53)	73 (62)	70 (71)	76 (75)	72 (75)	74 (74)	71 (74)	69 (72)	66 (64)	62 (60)

Note : I : Data in bracket show previous averages.
II : Soil temp. at different depths are mean of morning and afternoon observations.

SUMMARY OF METEOROLOGICAL OBSERVATIONS DURING 1977

Table 2. Silcooria, Cachar

Latitude 24°50′ N Longitude 92°48′ E Altitude 39.6m (a.m.s.l.)

Months 1977	Daily temperatures °C					Rainfall (mm)		Daily sunshine hrs.	Daily Soil Temp. °C (under grass)			Monthly evaporation (mm)	
	Mean Max.	Mean Min.	Mean	Highest Max.	Lowest Min.	Monthly total	Rainy days		Depth 5 cm	15 cm	30 cm	Open pan	Pen-man
January	24.5 (25.9)	10.8 (10.9)	17.6 (18.4)	27.7	7.3	9.4 (17.6)	3(2)	8.0 (8.0)	20.7 (21.2)	?	?	55.7	71.6
February	26.2 (27.6)	12.5 (12.9)	19.4 (20.2)	29.6	7.7	55.2 (50.6)	6(4)	8.2 (8.2)	22.4 (23.2)	?	?	69.0	97.4
March	31.4 (30.7)	18.6 (16.5)	25.0 (23.6)	33.9	13.2	57.2 (108.9)	8(7)	8.3 (8.1)	27.8 (26.8)	?	?	106.2	157.4
April	27.5 (31.8)	19.7 (20.4)	23.6 (26.1)	32.9	16.7	807.8 (263.9)	25(14)	5.3 (7.6)	25.7 (29.3)	?	?	78.0	133.5
May	29.4 (31.8)	21.7 (22.7)	25.6 (27.2)	34.5	18.8	728.1 (376.5)	21(15)	5.6 (6.6)	28.0 (30.5)	?	?	83.3	152.6
June	30.4 (31.5)	23.7 (24.4)	27.0 (28.0)	34.1	21.0	550.0 (612.4)	28(24)	4.2 (4.2)	29.5 (30.6)	?	?	67.4	137.5
July	32.7 (32.0)	25.4 (21.9)	29.0 (28.4)	37.5	23.3	521.4 (527.4)	28(27)	5.6 (4.4)	31.8 (31.2)	?	?	69.6	169.7
August	31.8 (32.2)	24.4 (24.8)	28.1 (28.5)	36.1	23.8	437.4 (433.9)	24(25)	5.3 (4.9)	31.2 (31.4)	?	?	75.0	155.9
September	32.5 (32.3)	24.8 (24.4)	28.6 (28.4)	36.7	22.7	143.4 (341.2)	18(18)	7.0 (5.7)	31.4 (31.2)	?	?	78.8	157.4
October	30.1 (31.3)	21.7 (22.5)	25.9 (26.9)	33.6	19.0	210.0 (203.8)	13(11)	7.0 (6.6)	29.1 (29.6)	?	?	81.3	131.9
November	28.4 (29.2)	18.9 (17.3)	23.6 (23.3)	31.8	16.0	48.4 (36.4)	2(3)	6.6) (7.8)	26.2 (26.0)	?	?	57.5	95.2
December	26.4 (26.8)	13.6 (12.4)	20.0 (19.6)	28.8	10.6	30.2 (9.6)	3(1)	8.0 (8.0)	22.8 (22.5)	?	?	52.5	80.1

PER CENT RELATIVE HUMIDITY

Table 2(a). Silcoorie

Hours of Observations IST	Jan	Feb.	March	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
0619	96 (98)	95 (97)	92 (94)	94 (91)	94 (91)	96 (95)	95 (96)	95 (96)	94 (95)	97 (96)	97 (97)	98 (98)
1319	49 (46)	47 (43)	47 (44)	74 (57)	70 (67)	78 (76)	74 (76)	75 (74)	70 (71)	69 (68)	67 (57)	55 (49)

Note : I : Data in bracket show previous averages.
II : Soil temp. at different depths are mean of morning and afternoon observations.
III : ? indicates data not available.

SUMMARY OF METEOROLOGICAL OBSERVATIONS DURING 1977

Table 3. Nagrakata (Dooars), West Bengal

Latitude 26°51' N Longitude 88°55' E Altitude 280.6m (a.m.s.l.)

Months 1977	Daily temperatures C°					Rainfall (mm)		Daily sunshine hrs.	Daily Soil Temp. °C (under grass)			Monthly evaporation (mm)	
	Mean Max.	Mean Min.	Mean	Highest Max.	Lowest Min.	Monthly total	Rainy days		Depth 5 cm	15 cm	30 cm	Open pan	Penman
January	22.5 (23.6)	10.9 (10.4)	16.7	24.8	5.1	0.7 (12.1)	2 (2)	7.1 (7.6)	17.8	18.6	20.0	62.9	66.3
February	25.7 (25.4)	13.0 (12.8)	19.4	29.6	7.3	29.2 25.2)	2 (3)	7.9 (7.1)	19.8	19.8	20.3	89.8	98.3
March	30.4 (29.1)	17.2 (16.4)	23.8	33.5	11.3	26.7 (37.8)	6 (1)	7.6 (7.7)	24.2	23.9	23.8	145.8	146.5
April	27.6 (31.1)	19.4 (20.1)	23.5	30.8	16.2	248.0 (138.2)	25 (10)	5.2 (7.0)	25.4	25.5	25.4	107.3	133.6
May	29.3 (30.7)	20.6 (21.7)	25.0	32.3	15.3	629.9 (352.7)	25 (20)	6.6 (6.5)	26.8	26.8	26.8	138.6	165.5
June	29.5 (30.3)	22.9 (23.3)	26.2	32.9	20.3	680.7 (893.9)	31 (26)	3.8 (3.9)	28.2	28.0	27.4	84.8	135.8
July	30.8 (30.3)	24.5 (23.8)	27.6	34.0	22.7	532.4 (1070.2)	28 (27)	3.9 (3.4)	29.6	28.8	29.6	98.6	142.6
August	30.8 (30.7)	24.2 (23.7)	27.5	34.1	23.0	1050.1 (760.7)	26 (27)	4.2 (4.1)	28.9	28.5	29.1	104.4	140.5
September	31.4 (30.6)	23.3 (22.8)	27.4	35.4	21.2	579.8 (552.8)	19 (22)	5.9 (5.1)	28.8	28.0	28.8	112.0	142.2
October	28.6 (29.8)	19.4 (19.6)	24.0	31.6	16.1	248.7 (220.0)	16 (10)	7.1 (7.7)	25.9	26.4	26.7	98.3	122.4
November	26.7 (27.4)	16.6 (14.7)	21.6	29.9	13.2	38.8 (18.8)	6 (3)	7.3 (8.6)	23.4	24.0	24.6	62.8	87.9
December	24.0 (24.8)	12.6 (11.5)	18.3	26.1	9.6	23.1 (3.4)	4 (1)	7.4 (8.3)	19.6	20.5	21.6	55.4	69.2

PER CENT RELATIVE HUMIDITY

Table 3(a). Nagrakata (Dooars), West Bengal

Hours of Observations IST	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
0634	91 (86)	80 (82)	76 (73)	90 (76)	91 (87)	95 (95)	94 (96)	96 (95)	92 (95)	91 (89)	92 (85)	88 (86)
1334	56 (51)	43 (49)	41 (44)	72 (53)	71 (69)	81 (82)	82 (83)	79 (81)	72 (78)	70 (67)	65 (56)	57 (53)

Notes : (i) Data in brackets show previous averages.
(ii) Soil temp. at different depths are the mean of morning and afternoon records.
(iii) Penman in mm means Penman estimation of evaporation from an open water surface.

SUMMARY OF METEOROLOGICAL OBSERVATIONS DURING 1977

Table 4. Nagri Farm (Darjeeling), West Bengal

Latitude 26°55′ N Longitude 88°12′ E Altitude 1158.24m (a.m.s.l.)

Months 1977	Daily temperatures °C					Rainfall (mm)		Daily sunshine hrs.	Daily Soil Temp. °C (under grass)			Monthly evaporation (mm)	
	Mean Max.	Mean Min.	Mean	Highest Max.	Lowest Min.	Monthly total	Rainy days		Depth 5 cm	15 cm	30 cm	Open pan	Penman
January	14.4 (15.1)	7.2 (7.8)	10.8	16.3	3.5	2.8 (19.6)	2 (3)	5.8 (6.1)	13.2	11.6	14.3	42.4	53.1
February	17.4 (16.7)	9.8 (9.5)	13.6	22.0	5.9	9.4 (20.6)	2 (1)	6.4 (5.8)	15.4	13.6	15.2	63.3	78.9
March	22.5 (21.5)	14.9 (13.1)	18.7	21.7	11.8	52.6 (47.0)	4 (1)	7.4 (6.9)	21.2	19.0	19.7	114.4	131.8
April	20.8 (23.7)	11.2 (15.9)	17.5	23.4	11.2	175.4 (102.7)	20 (11)	4.1 (5.7)	19.8	18.1	19.5	62.3	107.0
May	22.2 (23.9)	15.8 (17.1)	19.0	21.8	11.4	237.1 (191.0)	26 (19)	4.2 (5.2)	21.4	19.8	20.8	69.1	120.4
June	23.5 (21.1)	18.1 (18.8)	20.8	26.8	15.1	262.3 (110.8)	25 (25)	3.1 (2.9)	23.6	22.0	22.7	57.3	111.0
July	23.7 (24.3)	19.3 (19.3)	21.5	27.3	18.3	453.1 (657.1)	21 (27)	2.2 (2.1)	24.6	23.2	24.0	60.0	113.6
August	23.9 (24.7)	19.3 (19.1)	21.6	28.7	18.0	509.3 (472.7)	22 (25)	3.0 (3.3)	21.6	23.2	24.0	77.0	111.5
September	21.5 (21.4)	18.6 (18.2)	21.6	23.8	16.1	331.2 (321.7)	16 (20)	4.3 (3.9)	21.4	22.4	23.8	68.1	109.1
October	21.8 (23.3)	15.0 (15.8)	18.4	21.7	13.0	208.9 (137.2)	11 (8)	5.7 (6.6)	21.4	19.2	21.4	65.1	97.4
November	19.6 (20.5)	12.5 (12.0)	16.0	23.3	10.4	25.7 (11.1)	6 (2)	5.3 (7.2)	?	?	?	47.2	68.8
December	? (17.5)	? (9.2)	?	?	?	? (5.2)	? (1)	? (6.7)	?	?	?	?	?

PER CENT RELATIVE HUMIDITY

Table 4.(a). Nagri Farm (Darjeeling), West Bengal

Hours of Observations IST	Jan.	Feb.	March	April	May	June	July	Aug.	Septt.	Oct.	Nov.	Dec.
0637	70 (71)	62 (70)	61 (62)	81 (68)	85 (81)	91 (92)	94 (94)	93 (93)	85 (89)	79 (77)	76 (68)	? (69)
1337	68 (72)	56 (65)	55 (58)	85 (66)	80 (82)	89 (89)	90 (89)	87 (86)	84 (86)	80 (79)	77 (70)	(77) (70)

Note : (i) Data in brackets show previous averages.

(ii) Soil temp. at different depths are the mean of morning and afternoon record.

(iii) Penman in mm means Penman estimation of evaporation from an open water surface.

(iv) ? indicates data not available

SUMMARY OF METEOROLOGICAL OBSERVATIONS DURING 1977

Table 5. Thakurbari (North Bank) Assam

Latitude 26°48′ 35″N Longitude 92°42′35″E Altitude 92″45m (a.m.s.l.)

Months 1977	Daily temperatures °C					Rainfall (mm)		Daily sunshine hrs.	Daily Soil Temp. °C (under grass)			Monthly evaporation (mm)	
	Mean Max.	Mean Min.	Mean	Highest Max.	Lowest Min.	Monthly total	Rainy days		Depth 5 cm	15 cm	30 cm	Open pan	Pen-man
January	23.2 (24.1)	8.7 (8.8)	16.0	25.7	4.2	14.6 (22.3)	4 (4)	7.2 (7.8)	?	?	?	58.1	63.1
February	26.8 (26.2)	10.9 (12.1)	18.8	30.9	3.5	1.4 (16.3)	2 (4)	7.8 (6.9)	?	?	?	71.3	88.4
March	30.4 (30.2)	15.7 (15.3)	23.0	33.9	11.0	32.7 (51.6)	10 (3)	6.9 (8.0)	?	?	?	114.2	139.7
April	27.0 (30.9)	18.3 (19.5)	22.6	31.9	16.0	386.6 (171.2)	23 (13)	3.9 (6.7)	?	?	?	86.4	117.3
May	29.0 (31.1)	20.1 (21.8)	24.6	32.9	16.6	542.0 (214.8)	20 (15)	5.7 (6.3)	?	?	?	122.2	151.7
June	30.7 (31.6)	22.8 (24.0)	26.8	35.7	19.5	362.7 (458.1)	23 (23)	4.3 (1.2)	?	?	?	92.9	141.3
July	33.9 (32.0)	24.4 (24.6)	29.2	35.6	23.4	592.1 (522.8)	26 (25)	5.0 (4.8)	?	?	?	117.2	162.7
August	32.5 (32.4)	24.1 (24.6)	28.3	36.0	21.1	426.7 (308.6)	21 (20)	5.9 (5.3)	?	?	?	119.1	165.4
September	32.6 (31.7)	23.5 (23.1)	28.0	35.7	21.2	126.6 (312.0)	15 (19)	6.1 (5.5)	?	?	?	89.0	145.5
October	29.3 (30.6)	18.5 (20.9)	23.9	32.8	14.3	110.0 (192.6)	11 (11)	7.8 (6.6)	?	?	?	86.6	123.5
November	26.9 (28.3)	14.1 (15.1)	20.6	30.0	10.2	39.4 (9.4)	3 (2)	7.1 (7.8)	?	?	?	56.1	83.2
December	24.8 (24.6)	10.1 (9.5)	17.6	26.6	6.2	28.1 (16.4)	5 (3)	7.5 (8.0)	?	?	?	50.6	65.6

PER CENT RELATIVE HUMIDITY

Table 5(a). Thakurbari (North Bank), Assam

Hours of Observations IST	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
0619	93 (93)	92 (92)	87 (85)	92 (86)	89 (90)	94 (93)	94 (94)	92 (94)	91 (93)	89 (93)	92 (93)	93 (94)
1319	52 (53)	45 (53)	45 (59)	71 (60)	70 (69)	78 (77)	75 (77)	74 (76)	75 (75)	69 (71)	65 (62)	61 (56)

Note : (i) Data in brackets show previous averages.
(ii) Soil temp. at different depths are the mean of morning and afternoon records.
(iii) Penman in mm means Penman estimation of evaporation from an open water surface.
(iv) ? indicates data not available.

SUMMARY OF METEOROLOGICAL OBSERVATIONS DURING 1977

Table 6. Gungaram (Terai), West Bengal

Latitude 26°38' N Longitude 88°48' E Altitude 123.6m (a. m. s. l.)

Months 1977	Daily temperatures °C					Rainfall (mm)			Daily Soil Temp °C (under grass)			Monthly evaporation (mm)	
	Mean Max.	Mean Min.	Mean	Highest Max.	Lowest Min.	Monthly total	Rainy days	Daily sunshine hrs.	Depth 5 cm	Depth 15 cm	Depth 30 cm	Open pan	Pen-man
January	23.2	9.3	16.2	25.6	4.8	0.0	0	7.5	17.2	?	18.0	57.1	68.4
February	26.5	11.1	18.8	29.4	5.2	2.0	1	8.1	20.0	?	19.8	81.6	92.9
March	32.0	16.7	24.4	34.9	10.6	31.5	2	8.8	25.6	?	25.4	128.8	158.7
April	28.7	20.2	24.4	31.5	18.0	92.3	11	6.9	27.6	?	26.7	108.9	190.1
May	29.6	20.9	25.2	33.3	16.2	303.3	19	7.4	28.6	?	27.4	114.5	171.1
June	30.0	21.2	25.6	31.3	19.8	369.0	23	4.8	29.8	?	?	91.1	143.6
July	30.8	24.9	17.8	33.2	23.7	787.4	24	4.6	30.6	?	?	82.9	153.9
August	31.1	24.8	28.0	34.3	23.3	802.0	24	5.4	30.6	?	?	84.6	160.5
September	31.7	24.1	27.9	35.5	22.0	358.5	13	6.5	?	?	?	85.4	113.0
October	28.9	19.7	24.3	32.1	15.6	190.7	9	7.2	?	?	?	72.6	123.3
November	27.2	16.4	21.8	30.4	12.7	92.1	5	7.5	?	?	?	55.5	90.8
December	24.8	11.7	18.2	26.8	8.9	19.1	4	7.5	?	?	?	41.7	69.3

PER CENT RELATIVE HUMIDITY

Table 6(a). Gungaram (Terai) West Bengal

Hours of Observations IST	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
0635	93	91	78	89	90	91	91	93	92	95	95	95
1335	47	39	37	62	65	76	79	77	70	65	58	52

Note : (i) Soil temp. at different depths are the mean of morning and afternoon records.
(ii) Penman in mm means penman estimation of evaporation from an open water surface.
(iii) ? indicates data not available.